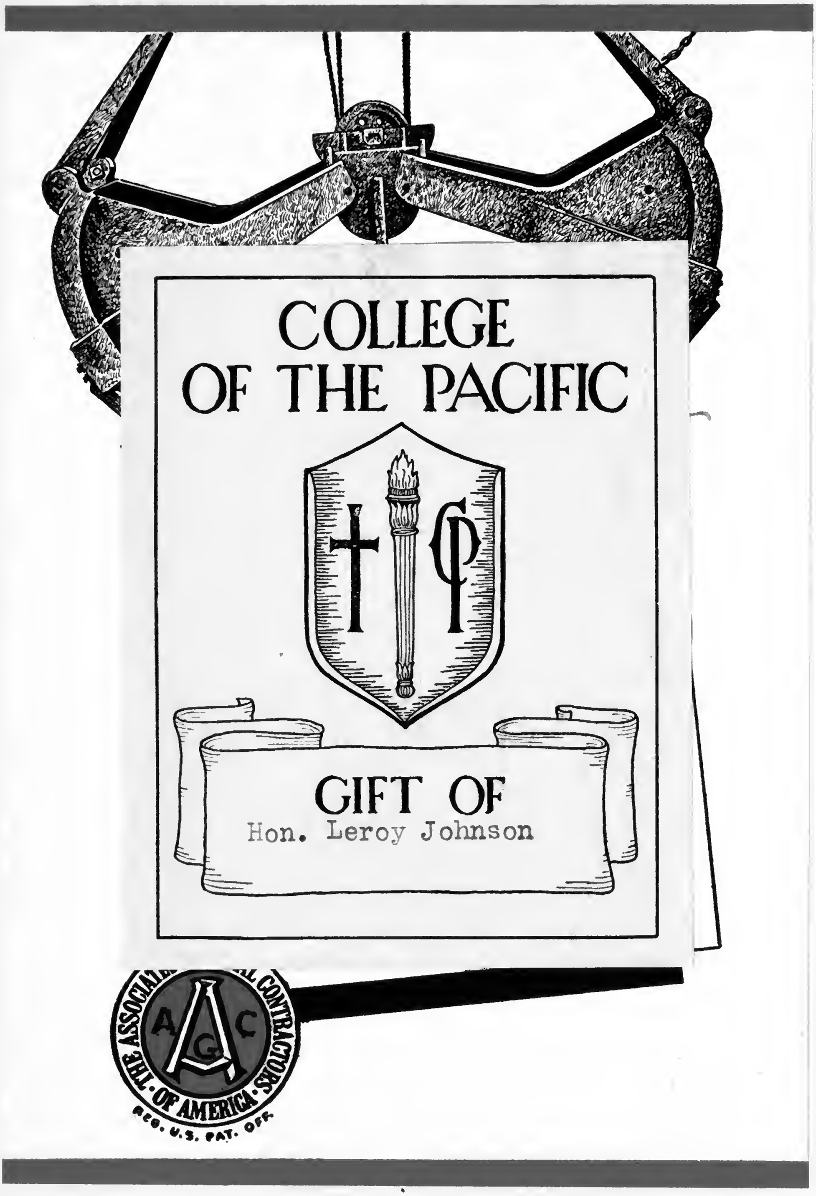
AMERICAN MIRACLE

By Van Rensselaer Sill


THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA
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The Story of War Construction Around the World

VAN RENSSELAER SILL

The Odyssey Press · 1947 · New York

FIRST EDITION

Foreword

THE men and women of the construction industry completed work valued at more than $49,000,000,000 for the war effort. This work constituted the world's greatest single construction program, and represented an expenditure of approximately $400 for each man, woman, and child in the country. The war was actually won by fighting men in the armed services. But they had to be supported by the products and the services of American industries. One of those industries was construction.

Camps which were complete cities had to be constructed before men could be trained and sent overseas. Factories had to be built before airplanes, tanks, guns, munitions, and other weapons of war could be produced in quantities sufficient to overwhelm the enemy. Yards had to be built before a bridge of ships and a seven-ocean navy could be launched. Bases had to be constructed before attacks could be directed at the enemy.

This construction work had to be completed before many other parts of the war program could be undertaken. Because of this, construction was the first major industry to attain large-scale defense and war production. By the time of Pearl Harbor it was converted 75 per cent to war work. Had construction failed in any part, other phases of the war program would have been hampered, perhaps disastrously. There were no bottlenecks in construction; work was completed at unprecedented speed.

A sense of urgency prevailed throughout the war construc-

tion program. Work drove ahead through all kinds of weather and other obstacles. Projects of unprecedented size and complexity were completed at speeds which surprised even the industry. The speed cost money, but to the extent that it shortened the war it saved lives.

As members of the armed services, construction men, with their methods and machinery, helped to develop the capacity for building airfields, roads, docks, railroads, pipelines, and for moving millions of tons of supplies with speeds never before attained in military operations. The nation's capacity to construct both at home and in combat areas was such that wartime Chief of Engineers, Lieutenant General Eugene Reybold, was able to report:

"By the war's end it was evident that American construction capacity was the one factor of American strength which our enemies most consistently underestimated. It was the one element of our strength for which they had no basis for comparison. They had seen nothing like it."

This book, while not in any sense a complete history of the construction experiences of the war, gives an account of some of the work which the men and women of this country completed for the war effort. It gives recognition to the accomplishments of millions of our people, who contributed to the winning of the war and who now are helping to build a greater America.

H. E. FOREMAN, Managing Director
THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA.

Preface

THIS book is about the strength of the little people. It's about their faith and determination. And it's about how they built for war. They did big things. They pushed the huge atomic bomb plants out of the earth; they drove the Alaska Highway through some 1400 miles of frozen wilderness; they cut the Ledo Road out of jungle and mud and mountains; and they built those mothers of death, our war plants. They built thousands of things throughout the world. In doing the job they fought bitter cold and intense heat; they worked on ice 10,000 feet thick; they fought desert sandstorms. Sometimes they built while machine gun bullets zinged around them and they flattened out in the mud until they thought their hearts would burst.

They don't claim any great credit for what they did. In fact, they say lots of people did a great deal more. To find that out, you only have to look on the streets and in the hospitals. You only have to visit Europe and the Pacific and look at those long rows of white crosses.

But their jobs were important. They were done by a great many people, by contractors and engineers and architects. And they were done by the dozer-men, the power-shovel operators, the crane-men, the welders, the carpenters, the steamfitters, the masons, the riggers, and hundreds of others. All in all, probably some 5 million men and women did the job.

They were able to do this $49-billion job because of their

brains and know-how, because of their stamina and guts. And also, although many of them were quite unconscious of it, because of a driving force that at times gave them a kind of second wind. For mixed up in these jobs were more than brains and skill; there were hatred and love and fear, and there was the determination to win regardless of cost. Sometimes it was a little like a man fighting for his life; but the only way he could fight was to build.

Often the resourcefulness and imagination of construction men meant the difference between success and failure. This, of course, has always been true. But the war period with its shortages of materials and equipment and manpower, with its desperate need for speed, called upon those qualities as never before. When they couldn't get steel, they tossed up fantastic structures with lumber, such as hangars for blimps, some of them as high as a 17-story building. When reinforcing steel was scarce they developed designs that cut it down to the amount required for the tie-rods and bolts of a wooden structure. On the fighting fronts they often had to build with whatever they could lay their hands on: a bridge from the carriage of a captured railroad gun, piers from sunken ships, floating drydocks from empty oil drums, dragline buckets from old boilers, pipe from the cases of Jap anti-aircraft shells.

At home, they developed new uses for old materials and experimented with many a substitute, such as glass and plastic pipes, asbestos, various composition boards, molded plywoods, impregnated woods, laminated wooded arches.

The war stimulated large-scale operations. Whole cities rolled off assembly lines. Homes, schools, churches, shopping centers, and other facilities were ground out like so many sausages—and some of the cities were very attractive. Some of the smaller contractors learned for the first time the tremendous

advantages inherent in big operations; some developed short-cuts, more economical methods, more efficient organizations.

Dumped into the laps of engineers and architects many technical problems looked impossible; yet they solved them, sometimes in most unorthodox ways. Some of these experiences will help us build faster and more efficiently in the peace; help us rebuild our cities and turn out the homes and highways and airports and dams and the other things we need.

In writing this story, it was often difficult to decide which jobs to tell about. There were so many of them, thousands and thousands. Some were huge affairs like the atomic bomb plants involving more than a billion dollars, some small and costing only several thousand. Obviously it would have been foolish to select them by mere size, for often the small jobs were as important and as outstanding in their own way as the big ones. The best way seemed to be to select them partly on the basis of being fairly typical of the kind of facility and partly for the story interest. This meant that thousands of jobs just as interesting and as outstanding had to be left out. But it was impossible to include all of them. The task of evaluating their relative merits would have been impossible without the necessary figures and detailed technical information, some of which is still classified as "restricted" by the Navy and the War Departments.

The stories about particular jobs do not mention the names of contractors, engineers, or architects, because it would be unfair to publicize a few and not mention others who did work equal in every respect to that in the jobs described. Furthermore, the projects, although directed by some of the best contracting, engineering, and architectural organizations in the country, were done not by just a few men, but by a great many million people, from the humblest day laborer to the most highly paid executive. The same viewpoint accounts for the fact

that specific locations are not named, because to give the location of a project would be almost the same as naming the contractor and the engineers, for a great many people in the industry.

If you are interested primarily in the statistics of the war construction job and in the work of our Federal Government during that critical period, you'll want to turn to the special supplement in the back of the book and study the figures and the statements prepared by authorities in the Government. But if you are one of those folks who get a kick out of building skyscrapers, or running a bulldozer, or watching the big power shovels and cat-cranes at work, you might try diving in after this toe-wetting process and let the statistics splash where they may.

V. R. S.

Acknowledgments

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The drawings are by Howard E. Chapman.

The source of each of the numerous photographs is indicated on the picture itself.

The author makes grateful acknowledgment for this assistance and for many other aids he received in preparing this book.

Contents

PART ONE

WAR CONSTRUCTION AROUND THE WORLD

1

Meet the Bulldozer

ALWAYS there were bulldozers. You saw them everywhere, hacking out ditches and carving roads and building ramps for sea planes. Sometimes you'd come across an army of them busily digging a coral pit or maybe you'd find them slicing off the top of a mountain. You never knew what you'd see a bulldozer do. Right now, for instance, one was sailing down into the jungle, its big parachute puffed out like a cream puff.

A marine craned his neck and squinted at it. "I never knew the damn things could fly."

"Sure—where've you been?" asked the man at his elbow. "They not only fly, but they swim, walk, cook, fight, and do everything else you want 'em to."

"That's right," added another. "I know a Seabee who's married to one. Greatest little wife he ever had. He says 'Waddle'—that's what he calls her—plowed under six Japs, then for weeks afterwards snorted every time she saw one."

The dozer hit the dirt hard, shook a bit, and settled down on her side. A mechanic looked her over, and they yanked her on her tracks. Then she started, sputtering and protesting, as a Seabee took her up the ravine. You could hear her crashing through the undergrowth.

That afternoon they started clearing out a spot for a landing field—a small one for fighter planes, but right under Jap noses on the next island, about 30 miles away. She was a baby dozer;

but she knew her stuff and strutted it proudly, busting over shallow-rooted trees and slicing away chunks of undergrowth. They got the airfield finished the next week, just 12 days after the dozer arrived.

There was nothing a dozer couldn't do. With the blade raised to protect you, she made a kind of waddling fortress that'd take you right up to a Jap pillbox, then she would drop her snout and cover the whole thing with dirt. You could use her to take the stench of dead Japs out of your nostrils—just turn her loose and in a few minutes she'd pile dirt over fifty of them. Or, as they did in Normandy, you could stick her blade on the front end of a tank and go merrily along plowing through embankments and thickets and Krauts all at the same time.

Maybe she wasn't the most spectacular weapon, but in her steel flanks she packed the strength of a thousand men. She helped put the planes on the clouds; she helped deliver men and food and ammunition; and she helped push around enough dirt on just one highway job to build six solid pyramids the size of the Great Pyramid near Cairo.

There were others, kind of distant cousins to the bulldozer. They worked side by side with her. All were part of the construction army that pushed our troops and matériel across Burma, over France and Africa, up the mountains of Italy, and from island to island across the Pacific. There were, for instance, the power shovels that ate their way through coral, clay, rock and tundra. There were the long-armed cranes that could reach down and pick up a fifty-ton steel girder as gently as you'd pick up a kitten. There were the squat carryalls or pans, with their humpbacks and scrapers, that'd cut off thin slices of dirt, pile them in their bellies, and cart them around for dumping on low places. They never seemed to stop, circling around and around, scraping up dirt, hauling it, dumping it. On the shorter hauls they took

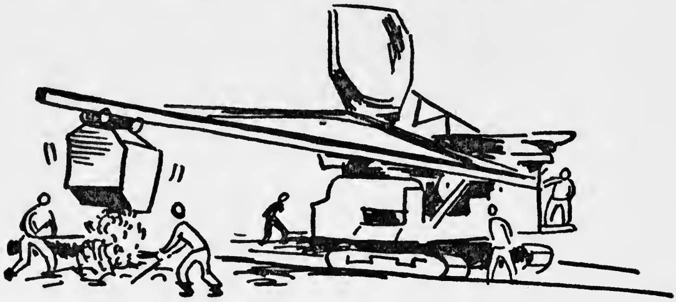
the place of three other machines: scrapers, loaders and dump trucks.

Then there were the pile drivers or steam hammers, steel box affairs hung from the booms of cranes. The box would hug the top of a pile, little plumes of steam would spurt out rapidly, and soon she'd be going, banging and clanging furiously, driving sixty-foot piles as easily as you'd drive stakes for your tomatoes.

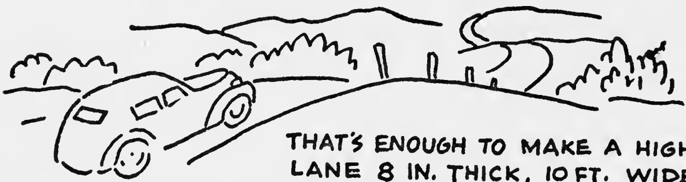
Another machine, the biggest and perhaps the most fascinating of all to watch, was the paver. Back home, you've seen this machine building roads. Out here, she built the biggest airfields, and on some islands she turned her talents to laying superhighways. You'd see her rumble out on a fairly level stretch after the dozers and carryalls got through. As she walks she gulps down great mouthfuls of sand and cement and gravel and water, spinning it around and around in her innards, then spewing out the wet concrete into a huge bucket she carries for that purpose. She sends the bucket running out on her out-stretched steel arm, opens it, and lets the goo gush out over the ground. As she does all this, she keeps moving. Trucks back up to her, fill her enormous maw, and clatter away for more mouthfuls. Her appetite is insatiable and she is ugly and noisy, but she knows her job. Always, behind her, you'll find a wide ribbon of concrete; good enough for the heaviest planes and trucks.

It didn't make much difference where you went, you'd see the machines and the Seabees and the Army Engineers. Sometimes they were right up on the fighting fronts with the dogfaces—throwing a bridge across a river, maybe just a small jungle stream, or maybe a railroad bridge across the Rhine. Or they'd be digging out emplacements for machine guns and anti-aircraft guns, or clearing beaches and cutting roads for the infantry. And they'd be building things like that while all around them hell was breaking loose.

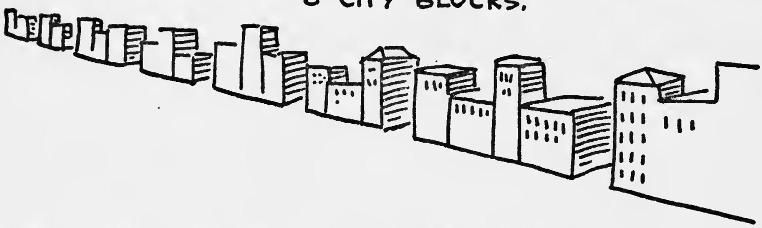
What the Pavers Did*



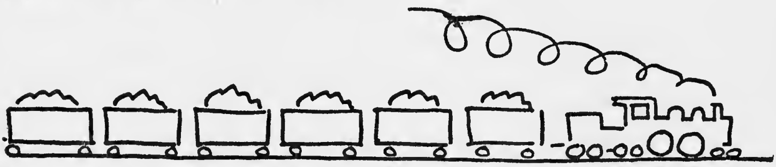
THIS MACHINE MAKES AND POURS 750 CUBIC YARDS OF CONCRETE IN 8 HRS.



THAT'S ENOUGH TO MAKE A HIGHWAY LANE 8 IN. THICK, 10 FT. WIDE, 4300 FT. LONG, OR THE LENGTH OF 8 CITY BLOCKS.



IT WILL HANDLE ABOUT 30 CARLOADS OF MATERIALS A DAY



* MODEL 34-E UNDER GOOD CONDITIONS

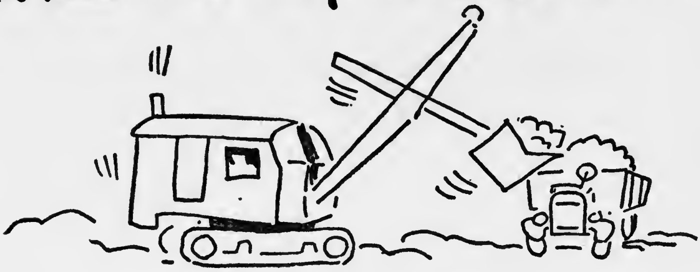
Farther back from the front, but not so far back that you'd call it cozy and comfortable, they'd be dozing out airfields and building warehouses and hospitals and barracks and docks and harbors and roads and just about everything else you can think of—that is, everything else it takes to move an Army and Navy all the way around the world.

And if you kept back-tracking, in some cases over some 14,000 miles of land and water, you'd find the same kind of machines and the same kind of men, building the shipyards and airfields and war plants. It would be a long road, from Assam, India, to Detroit, or maybe from Attu in the Aleutians to Tampa, Florida. But when you got home, if you could in some miraculous way roll time back two or three years, you'd see the same man who was running warehouse construction on Guam bossing a crew on a cantonment job, the same contractor who slapped a couple of hundred airfields on Pacific bases building a sixty-acre plane plant, and the same carrot-top engineer who threw two bridges across the Rhine designing a submerged shipway.

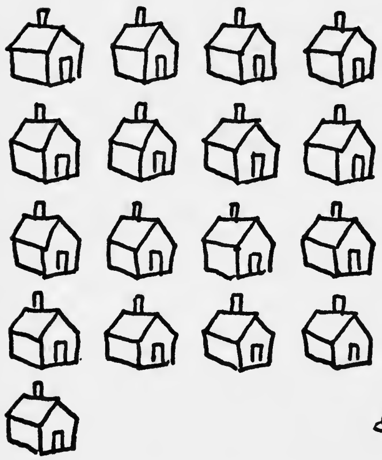
They'd all be pretty much the same men—the steel workers, dozer men, carpenters, power-shovel men, and the rest. They'd be running the same big jobs in the same big hurry—at home, because we needed the troops and planes and ships as fast as we could get them—overseas, because we had to throw troops and planes against the enemy as hard and as fast as we could.

On your trip back home, if you were coming by way of the Pacific, you'd fly over scores of bases. Some of them would be tiny pin points, others you wouldn't be able to see at all. But on them would be more airfields, more storage depots, ammunition dumps, tank farms, repair docks, hangars, and so forth—all built by the same men you saw building factories and skyscrapers and dams at home. If you flew back over the Atlantic, you'd pass the greatest of all arsenals, the United Kingdom, and the Atlan-

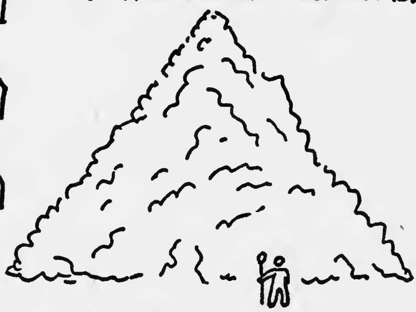
What the Big Shovels Did—



THIS MACHINE WILL DIG AND LIFT ABOUT 2500 CUBIC YARDS IN 8 HRS.*



THAT'S EQUAL TO THE DIRT DUG FOR THE BASEMENTS OF 17 AVERAGE SIZE HOMES



IT WOULD TAKE MORE THAN 300 MEN TO DIG THAT MUCH DIRT IN 8 HRS.

* 2½ CUBIC YARD CAPACITY UNDER GOOD CONDITIONS

tic bases stretching all the way from Greenland to South America. And each base would represent construction on a gigantic scale.

That's the thing that impresses you—construction everywhere. After a while you begin to feel as though the whole war was mostly a matter of building things. You begin to see the air war in terms of so many plane plants, so many airfields, engine testing laboratories, training stations, ammunition depots, tank farms and modification centers. You think of the fleet as so many shipways, drydocks, harbors, and remote island bases with their multitude of facilities for providing oil, water, food, repairs, and ammunition. You don't think of fire power as so many blazing guns, but as a way of hurling 4,500 tons of steel at the enemy in 15 seconds. That's the amount of steel all our ships could fire at once. It's equivalent to 112 freight-car loads of steel. But to you, as you watch the dozers and power shovels moving dirt around, this means so many blast furnaces and rolling mills, powder plants and ammunition-loading piers, warehouses and naval bases.

Soon, if you keep on watching one construction job after another, you get a distorted view of the war. You see it as though you were looking in one of those funny fat-man mirrors at the state fair. You lose your sense of proportion and you are tempted to forget that, after all, it is only one phase of the war, a mighty important phase, but still only one. If you're not careful you forget that there are dogfaces, that there are the men who sweated it out, and that some of them didn't come back. So you make up your mind to try to see it in terms of that dogface—hungry, tired, cold, and desperate. It was this man who had to do the killing. The whole idea back of all our war construction was to help him do it speedily and efficiently.

2

We Keep Our Powder Dry

EVEN when you have seen the airfields, the floating drydocks, and the endless rows of barracks and hospitals and warehouses and shops, it's hard to realize the bigness of the job.

When you think of the work in the Pacific, the Atlantic, Europe, Africa, Asia, and the States, the construction feat becomes a blur of a lot of installations and millions of men building things. Your trouble, of course, is that you think of it piecemeal, like the individual pieces of a jigsaw puzzle.

If you fit the pieces together the whole vast picture begins to take shape. It amounts to some $49 billion worth of construction, nearly half of it financed by the Federal Government and slightly more than half paid for with private funds. This is the money we used from June, 1940, to June, 1945, to build the things we needed for war. It's not the total cost of the war, which amounts to about $280 billion and includes the price tags on such little items as aircraft carriers, superforts, ammunition, and so forth.

Behind the cold construction figure of $49 billion, abstract beyond the understanding of all except a few financial wizards, is a story of how millions of men and women worked to protect their homes, a story that extends to the uttermost recesses of the earth.

It is a story of men working in temperatures of 40 and 50 below, spanning swamps in steaming jungles, driving highways through frozen tundra and over ice-choked rivers, and doubling

the productive capacity of the nation in five short years. It is the story of the world's largest construction job and like all big stories where life and death are at stake, it cannot be told in terms of billions of dollars.

It begins back in June, 1940, when Congress passed the National Defense Act, and when we started to defend ourselves. At that time, you'll remember, the German army had been fighting ten months.

On September 1, 1939, their bombers and fighters broke through the dawn over Poland and plummeted their bombs on helpless towns and villages. Two days later, Great Britain and France declared war on Germany. Yet they could do nothing to help Poland. In a month she capitulated, and during the next nine months country after country fell. Most of the British Army and 100,000 of the French were evacuated from Dunkirk. All Europe seemed lost and Britain was to be next.

About the time the National Defense Act was approved, Public Law 664 was signed by the President. This law granted authority to the Reconstruction Finance Corporation to set up the Defense Plant Corporation, which would finance a large part of the industrial construction necessary for national defense. Three months later, on September 14, the President signed the Selective Service and Training Act of 1940.

A month later the Second Revenue Act of 1940 became law. This Act permitted business men to amortize over a five-year period the cost of plants built to produce war materials. Thus they could charge off the cost of their war plants at a greatly accelerated rate. Other acts were passed, all aimed at increasing our production for defense.

We were getting ready. And we needed to get ready. We needed men; we needed raw materials; we needed all kinds of weapons, from bayonets to battleships, from Garand rifles to fly-

ing forts; we needed mountains of supplies—shoes, ammunition, gasoline, trucks, more than a million different items. And we needed them fast.

But before we could have any of them in sufficient quantities, we had to have construction. First we had to build the cantonments, the war plants, shipyards, airfields, aluminum plants, and a thousand other structures from which we could hatch the implements of destruction. We didn't have much time.

But it was not until September, 1940, that funds became available in substantial amounts. And by the time contracts had been awarded it was October. Then the dirt started to fly. In the South that winter was the rainiest in Weather-Bureau history. In the North snow piled up in great drifts and the temperature in some areas dropped to 30 below for weeks at a time.

The first big job was to build cantonments for our troops in training. We had to build shelter for 500,000 men by March, 1941, just six months away. By June, within nine months, the housing program called for sheltering 1,195,000 troops.

Now a cantonment is not just a few hundred barracks. It is a city in itself, complete with mess halls, bakeries, laundries, theaters, chapels, warehouses, streets, access roads, shops, hospitals. All the facilities you find in a modern city had to be provided, miles of water lines, miles of sewer mains, miles of electric-transmission lines. There had to be cold-storage plants, recreation buildings, and sometimes airfields and hangars.

Such cantonments are a far cry from the barracks and training centers of World War I. In 1917–18, our cantonments were little more than one-night stands. Troops went through them in a hurry; they got their specialized, more intensive training overseas. In this war we had to build for continuous use over a period of years. This meant better construction all down the line; and it meant properly constructed utilities of all kinds: electricity,

water, and sewage-disposal systems. Without such utilities public health would have been jeopardized.

Within nine months we had to build 50 camps and cantonments, 30 reception centers, 19 replacement-training centers, 52 harbor-defense projects, 16 air-corps projects, and 148 other projects—all part of the troop-housing phase of the Army's emergency-construction program. We had to do this at the worst possible time of the year. In the South the sites became so mired with mud that contractors hauled supplies and building materials in on sleds drawn by tractors. In other areas the cold became so intense that the ground froze solid to a depth of three and four feet. In almost all areas there were material, manpower, and equipment shortages.

But the cantonments were built and built on time. In fact, the Army's schedule was beaten. By June 30, 1941, enough of these cities had been built, some of them with a population of 60,000, to house 1,214,000 troops. The size of the job and the speed with which it was done were but a foretaste of what was to come.

Beside cantonments and camps, the Army launched about a half billion dollars' worth of ordnance construction. This was done in a hurry. Contractors, engineers and technical experts were called to Washington. Plans were rushed from drawing boards. The ordnance job during those nine months of 1940–1941 called for rush construction on 33 manufacturing plants, five ammunition-storage depots and eight field-service facilities.

There were TNT plants, ammunition plants, shell-loading plants, and others with equally grim purposes. The ordnance program as lined up that year meant constructing in record-breaking time more than 7,000 buildings, many of them great sprawling structures covering scores of acres, some highly complex affairs involving problems seldom encountered on normal peacetime jobs.

What the Scrapers and Carryalls Did

THIS MACHINE SCRAPES, LOADS, HAULS, AND SPREADS 720 CUBIC YARDS OF DIRT IN 8 HRS. (500 FOOT HAUL)

* 12 CUBIC YD. CAPACITY UNDER GOOD CONDITIONS

Then there were the airfields, hospitals, training stations, repair depots, aircraft-assembly plants, seacoast fortifications, and our Atlantic and Pacific bases. All over the country construction was on the march.

During the last three months of 1940 and all of 1941, we spent some $14.6 billion for constructing war facilities. Of this amount, about $2.3 billion went for Army and Navy installations. The rest was largely for building industrial and manufacturing facilities of various kinds, such as plants for turning out chemicals and planes, guns and explosives, and yards for building naval and merchant ships.

3

Full Steam Ahead

On a quiet, warm afternoon in December when most families were finishing their desserts at Sunday dinner, the news came. No one quite understood just what that attack on Pearl meant.

Things began to happen. On the construction front, our work paid dividends; now it suddenly became obvious that the speed with which we had built the cantonments would save lives; that the war plants so quickly thrown up might well mean the difference between a long war and a short one. But although construction was off to a flying start—it was the first industry to convert from peace to war—still the job before us was a formidable one. In the next year we had to do the impossible.

Even now, several years later, it is difficult to realize how we did it. When we look back on it, it almost appears like something out of a dream. We can still see the dozers and power shovels working through the night, construction jobs stretching out over hundreds of acres, great swarms of men and women working as though their very lives and the lives of their children depended on welding steel girders and pouring concrete foundations.

You can almost see the roads into construction towns packed with buses and trucks and jalopies. Everywhere we were building as we had never built before. Cornfields became endless miles of factories; cotton fields became plants for making explosives and planes; the prairies sprouted weapon factories. Our big industrial centers spread their arms out over the surrounding


Aerial Pho

Construction workers built the cantonments . . .

Bureau of Reclan

the power dams . . .

U. S. Steel Co

the mothers of steel and aluminum and magnesium . . .

Albert Kah

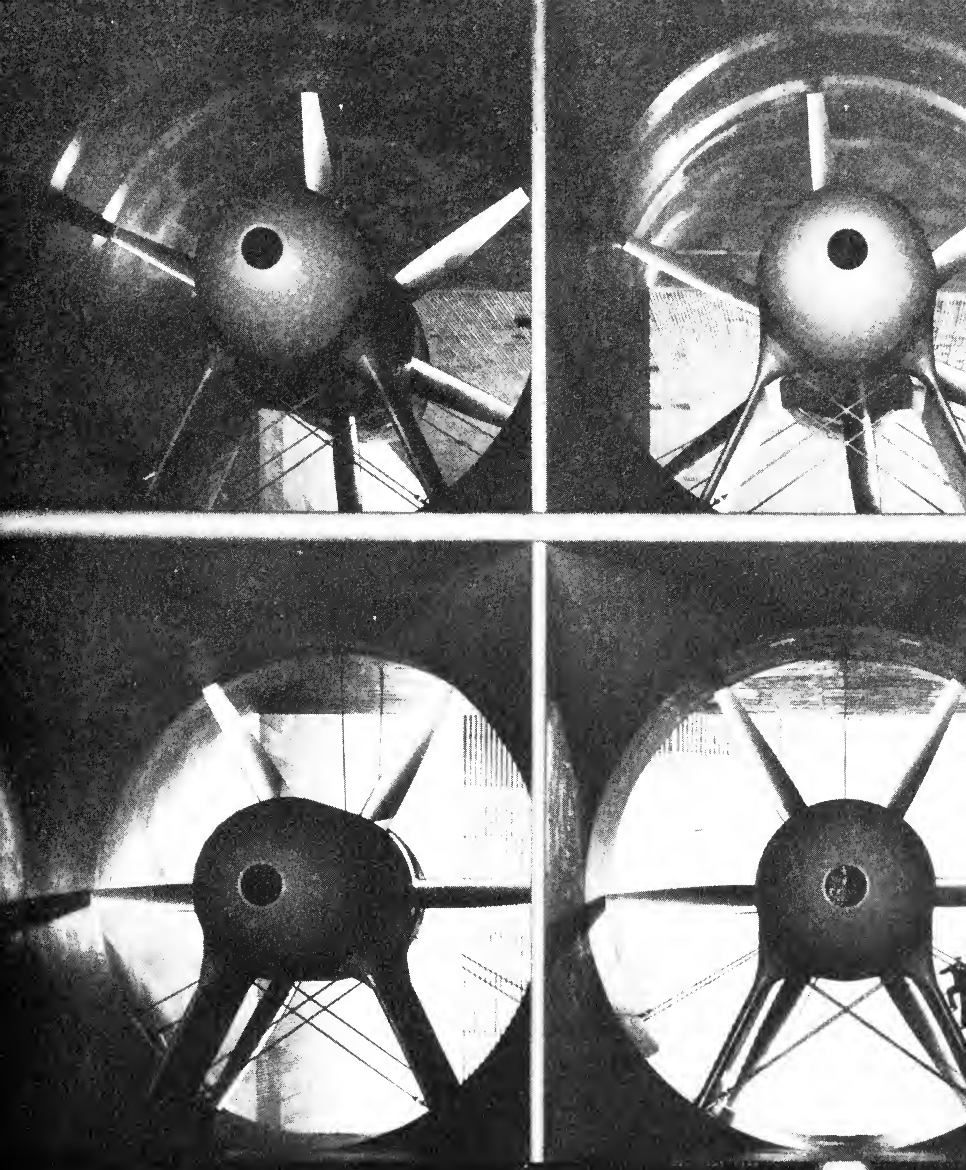
the plants for our weapons . . .

Library o

the homes for war workers.

Petroleum Administration fo

They built the steel arteries under the earth . . .



National Advisory Committee for

the hurricane factories to test planes.

U. S. Steel Corpo

Millions of things they built.

They are the dozer men . . .

U. S.

the power shovel men . . .

Bureau of R

the riggers . . .

Library of Con

the jackhammer men . . .

the truck drivers . . .

the welders . . .

Bureau of Re

the steel workers.

U. S. Maritime Com

They built to produce the hard muscle for war.

country, adding to their already swollen facilities plants that would turn clay into aluminum, ore into slithering, white-hot bars of steel, a queer mixture of chemicals into rubber. And along our coast line, from Maine to Washington, they built the birthplaces for a thousand ships.

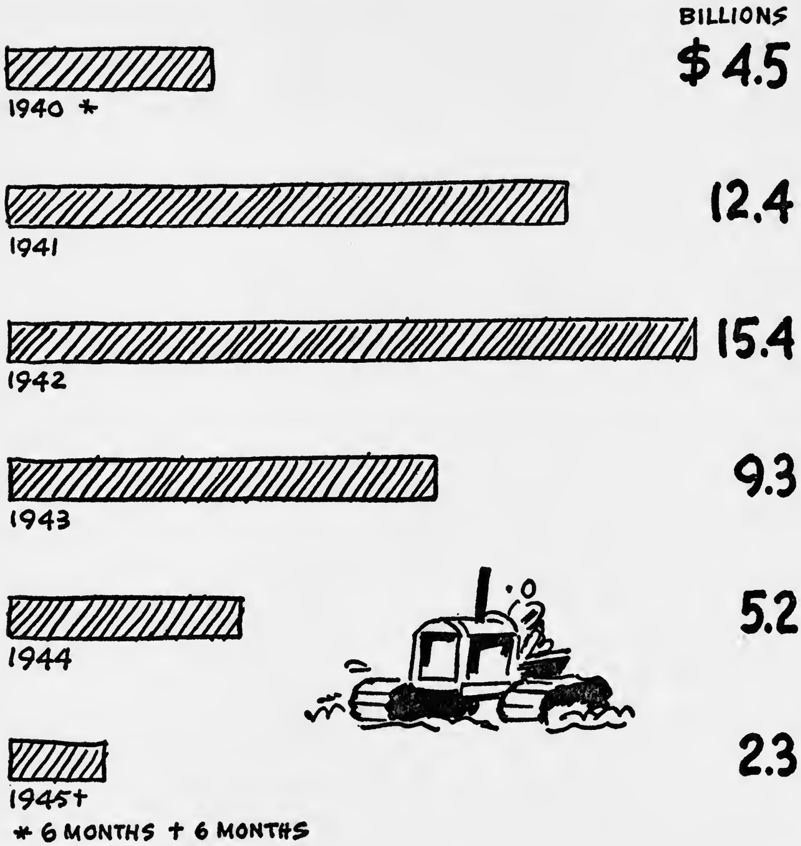
Many a field became solid concrete runways, flat as pancakes and as white as a bride's dress. Many a country town became an inferno of bulldozers and scrapers and riveters and gigantic cranes. Trucks loaded with cement and gravel and steel rumbled through narrow streets. Men and women, dirty and tired, pulled the levers, shoveled the dirt, hoisted the steel.

The results were dramatically impressive. In that year of 1942—a year that saw the March of Death, the desperate struggle for Guadalcanal, and the German victories in Europe—we sowed most of the seed from which would spring enough planes to darken the skies of Europe, enough munitions to enable our troops to wipe the enemy from the face of the earth.

These plants, these mothers of death, were made possible by our ability to build anything under the sun, our engineering skill and our construction know-how. But they, of course, were not solely responsible. Behind them, like some elemental force, were the anger and hatred and determination of every man, woman and child.

That we performed a construction miracle, few of us will doubt. Cold figures show that. In that year, on a dollars-and-cents basis, we more than doubled the facilities we had built in 1941 for turning out planes, ships, explosives, ammunition, nonferrous metals, machinery and electrical equipment. We spent 22 times as much as we did in 1941 for building synthetic rubber plants, 21 times as much for plants to produce aviation gasoline, and more than doubled our expenditures for military construction. And 1941, remember, was a big year, more than three times

We Did a $49 Billion War Construction Job



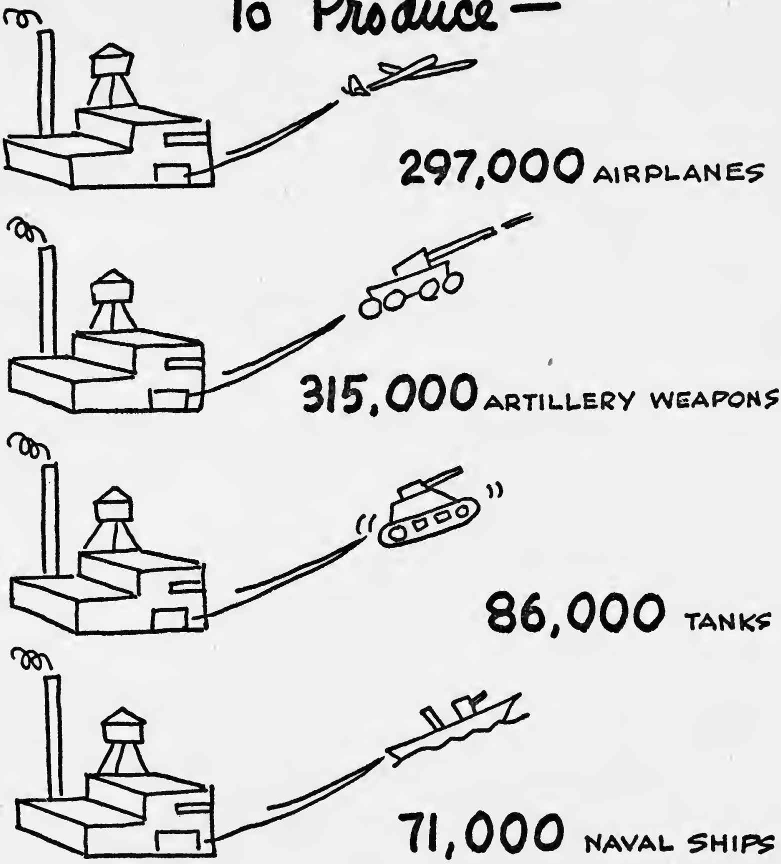
as much having been expended as we had spent to prepare ourselves in 1940. All in all we spent $49 billion on the defense and war-construction program. This is for the period, July 1, 1940, to July 1, 1945.

How does that $49 billion compare with other five-year figures? What does it look like alongside our outlays for construction during peacetime years when there were no particular equipment, material, and manpower shortages? In 1931–35, we did $17.2 billion worth of new construction. In 1936–40 the figure was $28.0 billion.

What did we get for the money? We got $49 billion worth of aircraft plants, steel mills, ammunition depots, shipyards, cantonments, hospitals, and so forth.

In five years we doubled the productive capacity of the country. We built endless facilities, and produced billions of dollars' worth of war material. We shipped hundreds of millions of tons. We trained millions of men. The job was so vast, the over-all figures so huge, that they are difficult for most of us to grasp—a little like trying to understand eternity or infinite space. So let's get down to a few specific examples, like building the Alaska Highway and a cantonment and an airfield and the plants for the atomic bomb and so forth.

We Increased Our Facilities To Produce —



4

Wilderness Road

THAT winter, some of the bridges were buried in solid ice. You could walk over the ice and see the bridges several feet below. In other river valleys the ice had pushed up to within a few feet of bridge floors. It was cold, 40 to 50 below, and it stayed that way for weeks. Ice formed in your nose, your feet and hands grew numb, and your lungs hurt when you took in deep breaths of air.

In the spring, along in April, the ice boomed and crackled like artillery fire, and the rivers lashed out like huge serpents. Mountains of ice tore down the streams, smashing the bridges, sweeping away everything in their path. In some cases, the ice cut off 18-inch piles as clean as a razor cuts your whiskers. Then there was trouble—lots of it.

The road was deep with mud, whole sections washed out, other sections drowned out. But mostly it was mud, and in it were mired trucks and road scrapers and dozers. In the spring you couldn't build much road; you just held on and did the best you could.

At first, that's about the way it was on the Alaska Highway. It was a "tote" or pioneer road built by Army Engineers with the help of contractors under the Public Roads Administration. It was about as primitive as a road could be and still be called a road—a streak of dirt through some 1,600 miles of virgin forest, running all the way from Dawson Creek, British Columbia, to Big Delta, Alaska, a distance about equal to the air-line route between Los Angeles and Chicago, or New York and Denver,

and practically all of it north of the Aleutians and extending almost as far west as Pearl Harbor.

When orders to build the road first came through from the War Department in February, 1942, they were simple and direct, tersely stating, "The pioneer road will be pushed to completion with all speed within the capacity of the troops." So much seemed to depend on time: supply lines to airfields in Canada and Alaska, supply lines to our outposts in the Far North, and the life of our bases in the northern Pacific.

The Japs had blasted Pearl Harbor, and three days later had licked the British Far Eastern Fleet off Singapore, sinking the *Prince of Wales* and the *Repulse.* Both American and British fleets were knocked out. About the same time, on December 9, the Japs took Guam. Wake fell on December 23, and Manila on January 2.

Defenseless, Alaska lay on the Great Circle route, the shortest distance between Japan and the States. In a telephone call to the War Department on December 23, 1941, Lieutenant General DeWitt said, "Admiral Freeman, Commandant of the 13th Naval District, has only five destroyers—three are used in Alaskan waters for protecting shipments of food and other supplies, and two are kept in Puget Sound. This force is so puny that he is almost helpless to assist me in what I've got to do up here." On January 3, he advised the War Department that there was not a single up-to-date fighter plane in the Alaska Defense Command and that the total available air force was 23 planes.

The Japs were free to do pretty much as they pleased. For three or four weeks after Pearl Harbor, General DeWitt reported, substantially every U.S. merchant ship leaving West Coast ports was attacked by submarines. On 41 separate occasions in December, according to Intelligence Reports, enemy submarines or surface craft were detected. This meant that building the pioneer

road was a race against time. We had to keep the Japs out of Alaska where they could establish naval and air bases, raid our shipping, and bomb Seattle, Portland and other cities.

At this time the road was merely a thin, wavering line on a map in the War Department in Washington. To most people it would have seemed like an ordinary kind of road, wiggling a bit as it climbed around mountains and dodged swamps, shooting straight as a bullet over the level stretches. It was sketchy, almost meaningless in places, for very little was known about some of the wilderness it was to tame.

Even if this map had been accurate, it wouldn't have shown the muskeg, the rivers frozen into huge ribbons of ice, the temperatures that dropped to 50 below and soared to 90 above. You couldn't have expected it to show the mosquitoes, hidden sheets of glacial ice, mud up to your thighs. To look at the map, you would have thought it was a nice little road running through pretty country on up to Fairbanks and touching, on the way, the airfields at Fort St. John, Fort Nelson, Watson Lake and Whitehorse. Nothing particularly difficult about it—just another one of those jobs.

First, the Army Engineers moved in. They began arriving at Dawson Creek, south of Fort St. John, on March 10, 1942, in subzero weather. They staked their tents in the bitter cold and started throwing up a supply base. The battle was on, a battle between man and numbing cold that knifed through you like a razor, between man and wilderness as thick as the bristles on a hog's back.

There wasn't much time to get men and food and equipment and supplies in before the spring thaw in April. Only a month to set up their bases all the way from Dawson Creek to Fort St. John and on to Fort Nelson, almost 300 miles away. They worked 22 hours a day in 11-hour shifts, in cold hovering around 40 below, and later through bottomless mud. Their trucks almost

sank out of sight. But somehow they established their bases and got some 900 tons of supplies in before the spring thaw wiped out the trail. Then they flew in more stuff. All kinds of supplies took to the air—dismantled machines, shovel booms, tractors, scrapers, drums of gas, and just about everything else.

The original plan was for the Army to build a pioneer road. Contractors working under the Public Roads Administration would haul their supplies and equipment over this road and build an improved, all-weather highway. It was thought that it would follow essentially the same route as the pioneer road. But speed in building the first road was the all-important thing. As the strategic situation became more and more desperate, the Army asked the Public Roads Administration to help with this first trail. Contractors were turned loose on it, working side by side with the Army Engineers. Some of them cut and dozed a pioneer road through virgin wilderness; others improved the primitive trail.

In this first year, about 11,000 troops and 51 contracting firms with some 7,500 men worked on the road. They drove it through with the help of air reconnaisance, which was followed up by examination on foot. They used snowshoes and dog sleds. In May, scores of survey parties were in the wilderness, supplied by canoe, float plane, and more than 60 pack-horse outfits.

Their orders were to get the road through fast. They didn't have time to be fussy about grades and curves and sight lines. They snaked around mountains rather than attempt much grading. They drove their bulldozers where the going seemed easiest, dodging muskeg, throwing temporary bridges across rivers, some of them the width of our Missouri and upper Mississippi. But they kept going, night and day, guiding dozers with flashlights, dragging their equipment across swamps, walking down the trees with 20-ton dozers.

The whole country was thick with trees, mostly spruce but some pine and aspen and poplar. They grow tall and spindly, and are shallow-rooted because of the dryness and the cold. Few of them are more than eight or ten inches in diameter, but so close together they seem to form a living wall of miles and miles of trees. Under them is a thick layer of dried moss, sometimes a foot or more deep. When you walk over it, your feet sink in to your ankles.

The road builders fought muskeg, which is peat or decayed vegetable matter packed with water. The stuff is found in poorly drained areas between mountain ridges and in undrained basins on the sides of mountains. It is treacherous, heaves in the winter, and is often completely impassable in spring. All in all, they corduroyed more than a hundred miles of muskeg. First they heaped on piles of brush, then laid logs on top, then more brush, and more logs, and finally a topping of gravel. In some places they built five- and six-decker sandwiches of brush and logs.

The spring was bad enough, but the summer, with temperatures soaring to the nineties, wasn't precisely comfortable. There were mosquitoes and flies and gnats, but mostly mosquitoes—mosquitoes that would shame your New Jersey mosquito into blushing bashfulness. They were whoppers and there are many stories about them. There is, for instance, the one about two mosquitoes who, after dragging a man out of his bed, paused on the doorstep and discussed the advisability of going back and getting his wife.

"The wife looks nice and juicy, a really tender morsel of loveliness," said the younger of the two mosquitoes. "Let's go back and get her."

"What?" asked the older mosquito, "And let our big brother get this guy?"

Over at Watson Lake the ground crews servicing planes had

to be constantly on the alert. A short time before, one crew had refueled with high-octane gasoline what they thought was a P-38. When the plane shook its wings and sang bass, they realized they had made a mistake. However, an official investigation proved this story to be slightly exaggerated.

Toward the end of summer, just as fall was creeping up, the first car got through. It had traveled the entire route from Dawson Creek to Big Delta through, as one man put it, miles and miles of nothing but miles and miles. Soon trucks were rolling north. The first land route to Alaska had been cut out of wilderness in less than eight months.

But most of this road was little more than a rough, winding trail. The grades were steep, curves sharp, bridges temporary. No one expected it would stand up and be passable in the spring when the whole road would turn into a dismal stretch of mud and swollen streams. So the job of improving it went on.

In the Yukon Territory and Alaska, winter pounces down on the country early. It starts to freeze in early September, and by October the land is frozen solid. During midwinter, considerable stretches of the highway between Lake Watson and White Horse are practically without direct sunlight. The sun is above the horizon for only six hours.

In the summer, the reverse, of course, is true. Then you can see the sun for 19 hours and twilight extends through the five evening hours. That's why the temperature will climb up to 90 and 95 degrees in the summer and plummet down to 50 below during the winter.

That winter of 1942–43 men worked two shifts of 10 and 11 hours each. The cold was so intense that it seemed to freeze the entire country into a solid chunk of ice. Gravel was blasted, heated, and then would freeze solid in the delivery trucks. Even dozers and trucks were whipped. Drive shafts and other metal

parts snapped. Frozen cup grease caused gear failures. Maintenance of the equipment became a major operation and repair shops along the road worked day and night.

During the winter the work was mostly on buildings, such as warehouses and shops and barracks. Sawmills screamed as they sliced out bridge timbers. They managed to get 15- and 20-ton loads of bridge steel through the wilderness and over the frozen roads—sometimes trudging ahead of the trucks and hacking away sheets of ice, sometimes pulling the trucks up icy grades with winches. They yanked their steel and timber to the banks of the Sikanni Chief, the Kiskatinaw, the Muskwa, and the Peace.

Then they swarmed out over some of the frozen rivers and built permanent bridges to replace the temporary ones that would be swept downstream with the spring thaw. They climbed up their bridge towers, out on their spidery trestles, and worked in darkness while the temperature fell to 40 below. Their hands were numb and they had trouble holding their wrenches; their legs were stiff, and they had to bury their mouths and noses in their parkas so that the bitter cold wouldn't jab through to their lungs. Night and day they worked this way, hour after hour, until they felt as though they would freeze to their steel girders and struts.

Some of the temporary bridges were completely encased with ice, just as though you'd freeze a cherry in the center of an ice cube. This was caused by the cold water under the ice freezing as it ran out over the rapids or a shallow section of the river. More water backed up under the ice and froze. Then water dashing downstream spread out over the top and froze until finally, in some cases, ice was formed some 20 and 30 feet above the surface of the stream. Sometimes whole river valleys were choked with a single, solid mass of ice. In the spring, such rivers did not go out with the usual crackings and booms, but melted down gradually.

Then the spring thaw hit the road. Huge chunks of ice roared down most of the rivers, here and there piling up far above stream-level, then breaking and crashing on downstream. The permanent bridges held, but most of the temporary ones were torn away as though made of cardboard.

After the thaw the road snaked rapidly forward. Over along Muncho Lake one of the few blasting jobs was started. The builders needed a toe hold for an improved road along the face of a cliff, so they hauled in 82 tons of explosives and sliced off 100,000 cubic yards of rock in a single blast. The 82 tons used in that blast were equivalent to 41 blockbusters.

As the summer approached, the sky brightened and became clear for weeks. Muddy sections of road dried out, supplies moved in, and bridge construction went ahead rapidly. It seemed a sure thing that the improved road would be completed during the '43 season. There was more banjo strumming in the evenings, more joshing and horse play. All down the line, from Big Delta to Dawson Creek, the workers were feeling their oats. The hardest part of the job was done. A few more months and they'd be back in God's country.

On July 9 and 10 it struck. It seemed as though nature had been winding up for the knock-out punch, the one blow dreaded above all others. That first day, the sky was dark and menacing. The men worked feverishly, glancing up at the sky, hoping some miracle would sweep the clouds away. Suddenly the sky burst and the water poured down. The rain continued for two days, drenching the entire area for 200 miles on either side of Fort Nelson. Natives said it was the heaviest rain in 50 years.

They fought it desperately. For days they sweated through water and mud, but they were helpless. The water dashed down mountain sides, gushed out in great streams from undergrowth and soggy moss, roared down through stream beds and swept over

the banks. It turned the road into a series of lakes and muddy swamps. In some places mountain slides buried the road under thousands of tons of dirt and rock and trees. In other places, whole sections of road were washed out. Hundreds of culverts were destroyed—smashed to splintery masses or sent spinning out over flooded valleys. The swollen rivers grabbed their temporary bridges and sent them rolling and whirling in the torrent downstream.

Day and night they worked in cold water, grimly holding on to undestroyed pieces of road, fighting to make the bad sections passable. Some camps were completely cut off from the outside. Rations ran low, but belts were tightened and the men struggled on.

Down by the rivers men climbed out over trestles and tried to salvage bridge timber; others fought their way downstream and snagged out timbers tossing in the currents. Other men lugged timber back from river banks where it had been stored near bridge sites for repair work.

About ten days later, on July 20, they had their road back in shape. Through traffic was rolling again. On the last stretches of improved road, they speeded up, often averaging three miles and more a day. In August the whole job was 70 per cent completed; in September, 80 per cent, and in October, 96 per cent. On that last date contract construction under the Public Roads Administration stopped, and from there on it was largely a matter of the Army Engineers keeping the road in condition.

This new and improved all-weather highway is 26 feet wide throughout its length with the exception of a 75-mile southerly piece which is 35 feet wide. It is well surfaced and built so that you can average 40 miles and more over the whole distance. Since it is east of the Rockies, it is far enough from the ocean to be beyond the range of enemy carrier planes, and the terrain and

climate are quite different from those of the Alaskan coastal country with its farms and thriving little towns.

In September, 1943, just as the road was nearing completion, 4 management and 77 other contractors were driving it through to the finish that fall. At that time, American contractors had 15,900 civilian workers on the road, Canadian contractors had 3,700, and the Public Roads Administration had 1,850. At the peak of construction, they used some 11,000 pieces of road-building equipment, 6,000 units of which were of the heavier types.

The figures, as on almost all of the larger war construction jobs, are big enough to choke an ox, and Paul Bunyan's blue ox at that. In building the road, contractors cleared and grubbed 6,413 acres of ground. They dug and scraped and pushed around almost 23,000,000 cubic yards of dirt and rock and muskeg, enough material to make more than 50,000 piles as big as an average two-story house. In addition, they hauled and spread more than 6 million cubic yards of ballast, and built 133 bridges with a total length of 7 miles.

There are other figures, long rows of figures marching across pages and pages. They are important figures, for in their neat totals are the aching backs and the frozen feet, the determination and the courage, of a people who believed in something so strongly that nothing could stop them from defending it.

5

Cantonment City

SOON the mercury would drop to the bottom of the glass. Dirt would be frozen three and four feet deep. The snow would pile up in great drifts and the wind would cut through you and you'd be stamping your feet and rubbing your nose and ears. There wasn't much time.

Somehow, there never was much time. Every job, every war plant, cantonment, shipyard, had to be finished in almost miraculous time—sometimes ten and twenty times faster than normal peacetime construction. If there ever was a time when the impossible had to be performed, this was it.

The Army knew it, the Navy knew it, and the contractors who arrived on the jobs knew it. Here in the building of a 15,000-man cantonment, near the Canadian border, it was the same. First they had to get their roads in from the railroad some three miles away, had to build roads through the site, some 68 miles of them. Then when the cold and snow hit, they'd at least be able to haul in their materials and supplies and equipment. True, it would be a battle to keep the roads open, but that was better than no roads at all.

So, the day after the contract for the cantonment was awarded, they were on the site, cutting out roads and grading, fighting to beat the first ice and snow of winter. At first they drove their dozers and scrapers and draglines 10 hours a day. Then they got floodlights and pushed dirt around and hauled crushed stone

through two ten-hour shifts. And when more men showed up, they worked three eight-hour shifts clear around the clock.

All night long you could hear their big trucks rumbling, could hear the quick puffing and whirring of the power-shovels, the sputtering of the bulldozers. The woods were filled with flickering, phantom-like figures sitting astride steel monsters. Always they were working. In the dim light of early dawn when the sky seemed about ready to burst, you saw them hacking out the wilderness with their clumsy rooters and dozers.

Then one day, it almost seemed like overnight, winter struck. The temperature dropped to 34 below and stayed below zero for about three months. Snow fell for days at a time, burying the roads in great drifts, blanketing the site and turning piles of lumber and pipe into huge white mounds. In normal times construction would have been stopped. But the workers continued to haul in more supplies—on some days as much as 75 carloads of lumber and hundreds of truck loads of other supplies. The ground, frozen as hard and tough as a sheet of solid rock, made their dozers look like flimsy toys. So they hooked as many as three big dozers to a rooter and tore into the frozen dirt. They thawed out land by burning waste.

Some of the buildings called for concrete floors, but before concrete could be poured the frozen earth had to be thawed out. They tried every known method without success. Then they tore up the dirt with pavement breakers, those pneumatic tools you see workmen use on city streets—tools which sound somewhat like machine guns and shake their operators into a kind of super St. Vitus dance. They dug out the frozen ground to a depth of two feet and trucked it away. Then they hauled in unfrozen dirt obtained from the bottoms of ditches they were digging for sewers.

Sub-zero weather would raise hob with their concrete piers and freeze water in the newly poured stuff. To prevent this, they placed one or two kerosene stoves in the excavation beside each newly poured pier, then smothered the hole with canvas and hay. Protection of their concrete walls proved to be an almost fantastic job. They had to build a wooden frame around the whole building area and cover it with canvas, then heat the inside of the enclosure with oil stoves, or salamanders, those drum-shaped affairs named after the fabulous lizard which was supposed to have lived on fire.

In fighting the cold, they spread some 600,000 square feet of canvas, equivalent to a strip a hundred feet wide and more than a mile long. They heated their enclosures with 450 oil-burning salamanders and 6,800 stoves, burning some 230,000 gallons of fuel oil.

They managed to keep their roads clear by running a fleet of nine snowplows and snow-loaders day and night, in the worst weather. In addition, they used power graders as they became available from other jobs. Over the roads they lugged 34 million board feet of lumber and 27 carloads of nails. The lumber amounted to 1,360 solid carloads. Most of it was hauled directly to the site where it would be used, but some had to be prefabricated first. This was trucked to one of the 14 sawmills.

In throwing up the 700 frame buildings for the cantonment, the work was divided along specialized lines rather than according to the usual method of division into a certain number of areas. As soon as one crew finished the foundations for a building and moved on to the next job, another group would start throwing up the skeleton. They were followed closely by another crew who enclosed the building and laid the subfloors. Next came the roofing crews, and after them men to install windows and

doors, and then the workers who did the plumbing and heating and electrical work. After this, other men installed the finished floors, partitions, insulation, shelving and equipment.

If you could have seen these crews swarming from building to building, each doing its own specialized job, you would have been reminded of some giant assembly line. Building after building seemed to grow out of the ground. One morning you'd see a number of bleak wooden skeletons, snow piled on the joists and rafters; a week later they'd look like completed structures, with siding and roofing and windows all installed.

Not all of the 700 buildings were barracks. In fact, only 240 of them were built to house troops. The rest included a church, a laundry, a bakery, two movie theaters, and various headquarters buildings. There were 81 mess halls, a 540-bed hospital, and 116 big warehouses. In addition there were buildings to house and service some 2,500 tanks, mortar carriers, personnel carriers, etc.

They pushed this city up out of frozen wilderness in about six months. In doing it they grubbed out some 850 acres of scrub pine and oak, carved out 68 miles of road, drilled two 150-foot wells, laid about 30 miles of water main and around 25 miles of sewer. It was a battle against wilderness and cold and snow, but the camp was ready when the first group of 4,300 troops streamed in. More and more troops poured in with their tanks and guns and supplies, but the contractors were through.

6

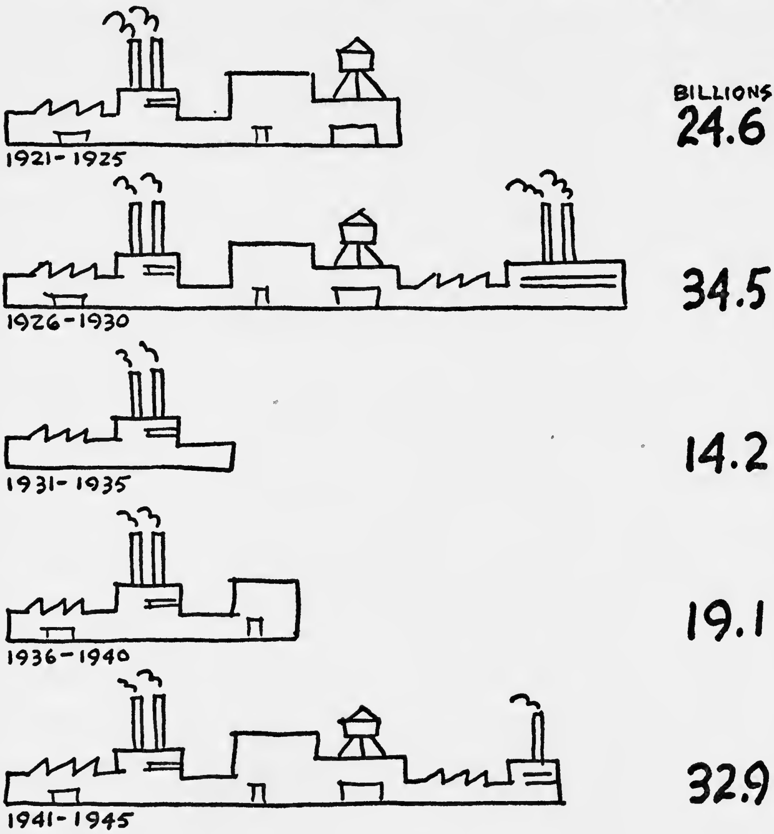
Cities That Grew in the Night

THAT night Jack O'Toole walked the streets until his feet ached and his legs were so tired he could hardly move. Around three o'clock he crawled into a garage and slept on a pile of newspapers. The next morning, stiff and sore, he tried to find a room—any room, anywhere. It didn't make much difference if it had ten cots in it, if the walls were half falling down, if it was a mile outside of town. He had to find a place to sleep. So did millions of others who were swarming into war-production centers.

It was the same story everywhere: on the East Coast, in the Middle West, the South, on the West Coast. The towns were swamped. Mobile, Alabama, jumped from a prewar population of 78,000 to one of 150,000. Portsmouth, Virginia, soared from 15,000 to 80,000. In a matter of months other places doubled, tripled their populations.

We had to have homes, and we had to have them right away. But we were fighting for our very existence. It was a question of using steel for homes or for tanks, of using lumber for houses or for crating war supplies, of somehow getting along without or maybe losing everything we possessed. So the Government compromised. It permitted only a limited number of homes to be built and those only for war workers and their families. It sharply curtailed the use of critical materials, like steel, copper, zinc and lumber. It chopped the maximum size home that could be built down to pretty near the size of a large chicken house. It stuck partitions in abandoned churches, old motion picture theaters,

Non-Residential Building Doubled During the War Years



big houses in the older sections of town. It did everything it could to make ten rooms where only two or three had been before.

The limited number of homes that could be built because of government restrictions, far below the normal peacetime average, had to be built in a hurry in spite of man-power shortages, lack of materials, old equipment, and transportation tie-ups.

Take the case of ship production in the Northwest. The towns of the area were bursting with thousands of families working in the shipyards, but more and more workers were needed as yard after yard went up in record time. So they built homes and they did it so fast you had to keep moving or they'd build one around you. They built a city, a good big one with a population of 40,000 persons.

They turned their bulldozers loose on 650 acres of truck land reclaimed from the Columbia River. They brought in their heavy equipment, mountains of lumber, and endless truckloads of cement. Three thousand men and women tore into the job—the women worked right along with the men—laying flooring, erecting partitions, throwing up the skeletons for 700 apartment buildings.

Not only did they build the homes, they built about eight miles of city streets and a water system supplied by wells as deep as a 16-story building is high. They laid eight miles of wood-stave pipe for the water mains, put in sewers, built schools, commercial centers, community buildings. All in all, they used about 44 million board feet of lumber, enough to make a pile 100 feet square and as high as a 36-story building.

When they had driven the last nail, a complete city, the second largest town in the state, stretched out before them over what only nine months before had been fields of carrots, lettuce and spinach. And every morning more than 10,000 workers from their city were pouring into the shipyards of the surrounding

area; every day more and more Liberty ships were sliding down the ways.

Although they may never have thought about it especially, no doubt many of the construction workers who tossed up this city would have been interested in how other construction workers had built the shipyards in which those ships were born. Still other construction men built the plants that provided the ships with their cargos, built the wharves and improved the harbors from which those same ships set sail, and then moved to all parts of the world to make more ports, to erect gigantic storage depots, and to build airfields, roads, railroads and bridges so that those supplies could be hauled to advance bases.

On the East Coast, near another shipyard, another war city rose. This city, consisting of 5,000 homes and the usual commercial facilities, had a population of some 20,000 persons. It was built in five months, production sometimes running as high as 300 homes a week. Translated into terms of 40-foot lots, that means a street of homes about 2 miles long in a week.

The builders' first job was to convert an old fertilizer plant into a home-making factory. They yanked a boatload of salt out of the plant, knocked out partitions, put in their motors and power saws and jigs. They built more assembly lines outdoors under canvas, took over and converted six hosiery mill buildings, erected dormitories, recreation rooms, kitchens, canteens, dining rooms, and offices. Then they were ready to start building homes, almost, as someone said, like grinding out sausages.

They built them on jigs and assembly lines. Into one end of their prefabricating plant went lumber and insulation and other materials; out of the other end came wall panels, ceilings, roof sections, floor sections and partitions. Even the pipe for plumbing was cut and assembled in the shops. Then they hauled the pieces

out to the site and put them together somewhat as you'd fit together the pieces of a jigsaw puzzle.

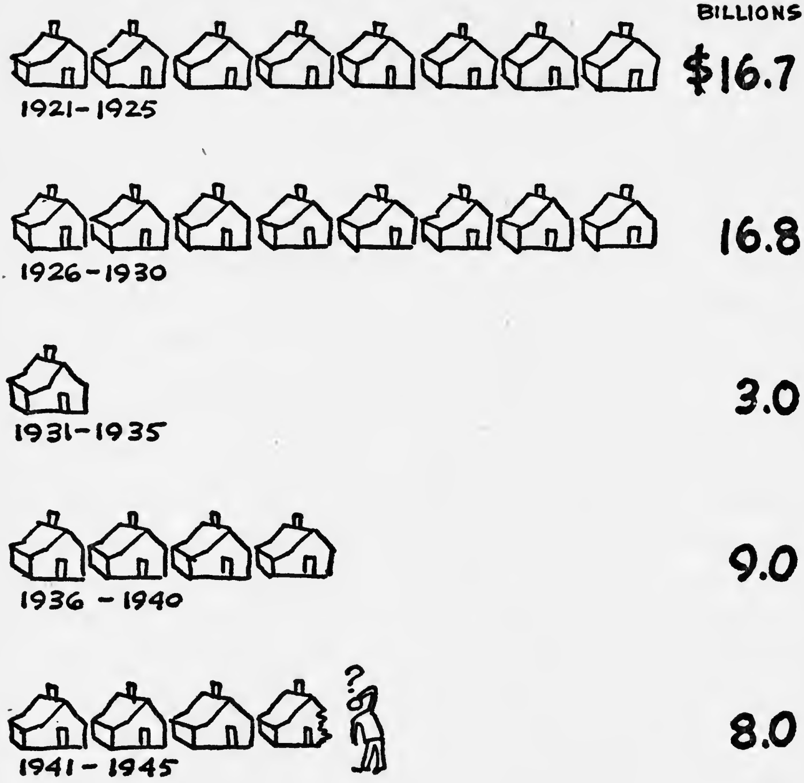
At first the going was a little slow; it took time to catch on to this newfangled assembly-line construction. A week after they started fitting the pieces together on April 7, 1942, they were turning out eighteen homes a day. Then what at first had seemed a complex operation became a routine job. By April 20, they were making 23 homes a day, by May 14, 39 homes, and on June 5, they built 60 of them. When they really got going, they were tossing walls up in 18 minutes, roofs in 8 minutes, floors in 23 minutes, and ceilings in 12 minutes.

Their standard house was 24′ 3″ by 28′, and had two bedrooms, living room, large kitchen and bath. All were demountable, held together by carriage bolts and lag screws, and could be taken apart in a few hours with the loss of only $22 worth of materials. The total contract for 5,000 homes was $14 million, an average of $3,000 per home.

Out in California, men working on a large-scale, mass-production housing project turned out a total of 1,500 homes at an average rate of a home every seven hours. Here, as in other big projects, workers were armed with plenty of power machinery. With it a man could cut 100 rafters an hour, dig 450 pier holes for foundations in a single eight-hour day, and cut framing in a fraction of the time required by old hand-saw methods. In the mill yard, for instance, they sorted and graded 250 carloads of lumber, fed 9.5 million board feet through the four saws on roller tables in the cutting yard. And after they had cut the framing for 1,500 homes, they assembled window and door frames.

More and more records were hung up. All of them were achieved through the use of mass-production methods, and

We Spent This Much for Building Homes



through site or off-site prefabrication, or a combination of all three. Some jobs stuck to off-site prefabrication methods, whole houses being made at distant plants and trucked to the site. One prefabricating plant made homes in large sections; the one-bedroom home in two sections, three-bedroom homes in four sections. Each section was eight feet wide and extended the full length and height of the house; each was shipped complete with furniture, plumbing, wiring, etc. Within a few hours after the sections arrived on the site, families were moving in.

When the whole war-housing job was added up on August 31, 1945, the date the program ended, contractors found they had built homes for some 1.8 million families. The figure includes all types of dwellings: apartments, detached homes, dormitory units, converted homes, and other kinds. Of this number a million were privately financed and about 830,000 were built with government funds. The total cost was almost $8 billion for the five-year period, July, 1940 to August, 1945.

Although this is far below the amount spent for housing in a normal peacetime year, it was enough to do the war job. The fact that it was done so speedily, in spite of material and labor shortages, made it possible for thousands of war plants to keep their assembly lines rolling and to hang up records for the production of ships, planes, tanks and the countless other things required for war.

7

Wings from a Bulldozer

ALTHOUGH the bulldozer hasn't as yet grown wings, it gave wings to thousands of war-birds. You see big bombers high in the clouds with their great wings outstretched, their motors droning, and it hardly seems possible that they sprang from mud and dirt and concrete and endless rows of machines. A fighter plane roars and is gone. A bulldozer wallows and pants in the mud, pushing rolls of ooze, moving forward clumsily, sputtering and spitting behind its steel snout. The relationship between dozer and plane seems remote.

Yet dozers and power shovels and scrapers made it possible for the great birds to leave the earth. Take, for instance, a big airport, near a bomber plant in the Middle West. At first there were oat fields gleaming in the sun and patches of green corn and country roads lined with maples. Then, one morning, farmers saw bulldozers and power shovels and other heavy equipment streaming over the roads. All during the summer they heard the dozers snorting savagely, saw power shovels eating their way through hills and the big scrapers scooping up several truckloads of dirt at a single crack.

As the days grew shorter and the air was filled with the sharp bite of fall, men brought in batteries of lights and turned night into day, so that two eight-hour shifts could sweat it out. They fought rain and mud and snow; fought sandstorms so thick with grit you could hardly see three feet in front of you.

The field had to be ready for the first bomber rolling off the

assembly line in the plane plant. If the airport was not ready, bombers would pile up and all the production in the world couldn't lift them a single inch from the ground. At first, the contractors estimated they had 270 days to do the job, then the time was cut to 120 days. The entire area became a morass of mud and trenches and mountains of dirt. The water table was only three feet beneath the surface. This meant the entire field had to be drained. They dug a ditch varying from 20 to 36 feet deep for the main sewer, laid the main sewer pipe, which ranged from 2 feet to 7 feet in diameter, and then dug lateral trenches for smaller drains that would connect with the big sewers, turning the whole area into what looked like a mammoth waffle iron. All in all, they buried 75 miles of pipe under the field.

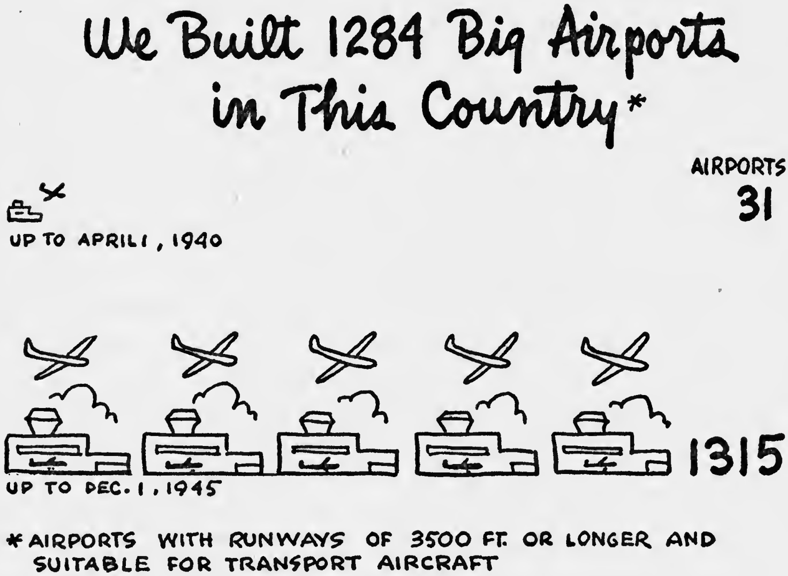
There wasn't time to do the drainage job and wait until the field dried out before starting the pavers. So they did all the operations at once. In some areas they drove their hump-backed scrapers; in other areas their pavers were laying slabs of concrete; in still others their dozers and scrapers dug the deep ditches, while wheel-type diggers cut out the innumerable shallow trenches.

Six paving outfits were used, four of them the biggest in the world. As they couldn't pipe water to the pavers because of trenches which were being dug in other areas at the same time, they used trucks and hauled in 240,000 gallons a day.

Down by the railroad siding two batching plants were set up, which made the dry mix for the pavers. Into the maws of these two giants went thousands of tons of sand and gravel and cement; out came the dry mix, pouring down into the trucks which were circling by them in never-ending lines. It took just 15 seconds to load each truck. Each day they hauled 5,000 tons of sand and gravel and 900 tons of cement. When the weather was fair, they laid one and a half miles of twenty-foot concrete slab a day. In

94 working days they made and put down 66 miles of slab, enough concrete to completely cover 153 acres.

They did the whole job, drainage, grading, and paving in four months. It was ready for those bombers the minute the first one stuck its nose out of the plant. Soon this first one roared down the runway, kissed the concrete good-bye, and was soaring in the sky. It wheeled, circled, became a tiny speck and disappeared. It was followed by dozens, then by hundreds, until finally the skies of Europe and the Pacific were dark with them.



8

Steel Hearts over the World

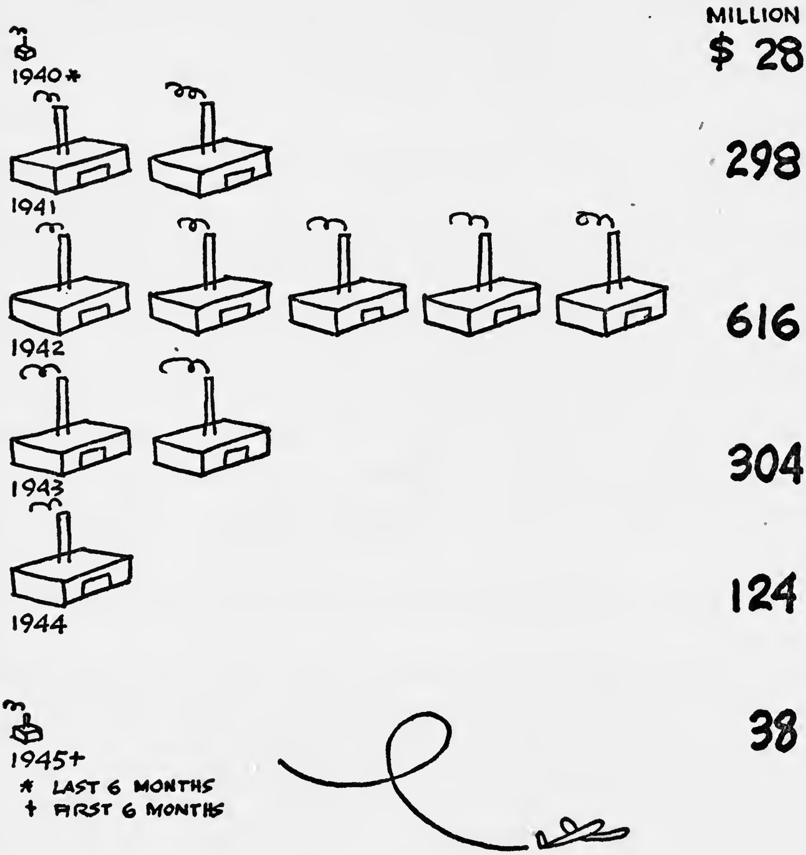
At the time it was a top secret, as tingling with mystery as a detective story. For in this plant would be born the engines for the world's biggest bombers—the same planes General Henry H. Arnold spoke of when he referred to Flying Forts as the last of the smaller bombers.

The construction job makes Willow Run look like an average kind of place. One of the buildings is spread out over 80 acres, about 50 city blocks of concrete and steel and miles of machines. You could put Willow Run in it and still have room for 20 baseball diamonds. And if you wanted to see clearly from one end to the other, you'd have to use binoculars. The complete plant, consisting of twenty buildings, sprawls over 500 acres. Around it is a fence four miles long.

The plant had to be gargantuan. Into one end flowed ingots of steel and aluminum and magnesium; out the other end rolled highly complex and delicately adjusted engines capable of pulling 70 tons of metal through the blue at 365 miles per hour.

In performing this magic that would change the metals of the earth into great throbbing hearts, we tossed many a building out of the earth. We built foundries for pouring white-hot aluminum and magnesium, forge shops where red-hot chunks of steel were pounded into various shapes, die shops where the dies for shaping thousands of intricate parts were made, shops for turning out hard steel tools, and the main building where parts were machined and assembled into engines.

We Built Plants To Make Our Planes



There were other facilities: parking lots for 13,000 cars, one of them using enough surfacing to pour a normal highway 40 miles long; more than 100 miles of sewer pipe and some 50 miles of water and gas mains; enough utilities to service a city the size of Terre Haute, Indiana, or Troy, New York; a boiler plant capable of producing enough power to keep warm and comfortable sixteen city blocks of three-room apartments.

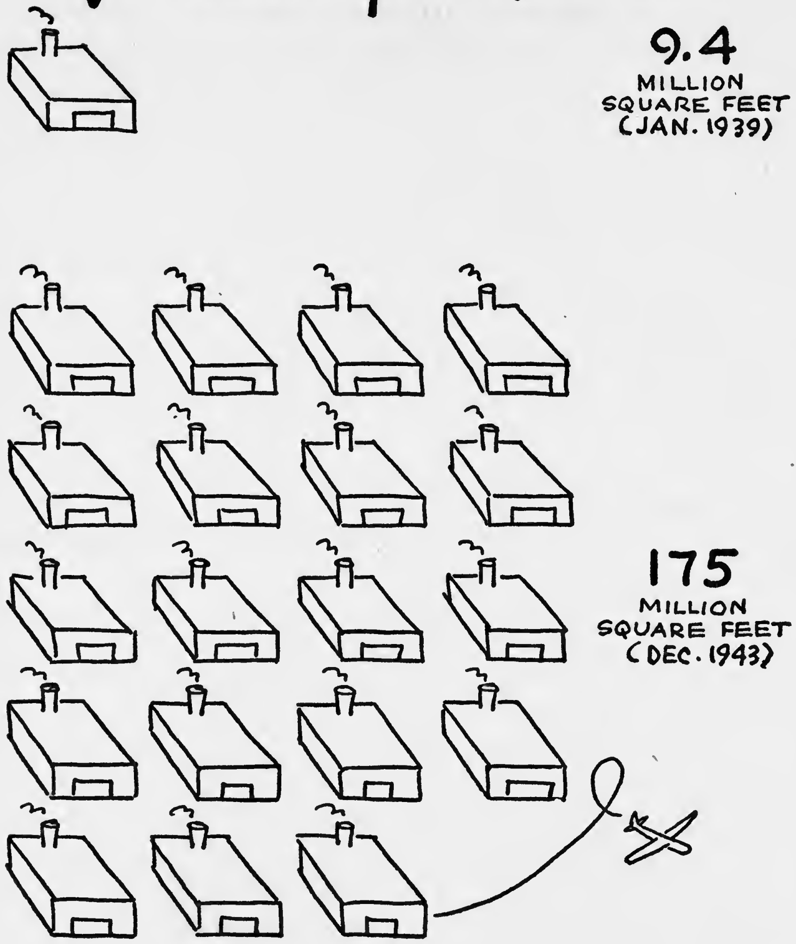
The size of this job even dwarfs those giants among buildings: the Merchandise Mart, Chicago, and the Pentagon building, near Washington, D.C.

To look at the finished job, which required more than 200,000 blueprints, you'd think maybe it would take four or five years to build. They did it in just twelve months. Early in June, 1942, they started carving out roads, digging foundations, hauling in supplies. When they really got going, they were hauling in some 800 truckloads of building materials plus 150 carloads of cement and sand and stone daily.

Before they had even started, the architects and engineers were suddenly faced with an almost insurmountable difficulty. They had completed the plans, when the War Production Board tightened up on the use of steel. Big plants of this type eat up vast quantities of the scarce metal. So the engineers discarded some of their old plans, reworked others, and came up with a new method of concrete construction that reduced reinforcing steel from 5.5 pounds per square foot of floor area to 2.6 pounds. This was done by using relatively long spans and a new type of arch-rib concrete construction for the roof. It succeeded in cutting down the amount of steel to what would have been used for bolts and tie-rods in a wooden plant. All in all, they saved enough steel to build more than 600 medium tanks or 14 destroyers.

They couldn't get metal for their heating and air-conditioning ducts, so they used sheets of asbestos cement and saved about

More Floor Space for Making Airplanes*



* PLANTS FOR AIRPLANES, GLIDERS, ENGINES, & PROPELLERS

600 tons of galvanized iron. As copper was scarce, they revamped the design for the electrical installations and saved 100 tons.

No ordinary methods of construction were fast enough. They had to figure out short cuts, invent new methods. One thing they did was to build a series of enormous forms mounted on wheels. Then they proceeded to pour one of the world's largest industrial plants pretty much the way kids pour mud pies into a cake pan.

Here's the way they did it. First they ran in their roads and railroad sidings. Then they started bringing in their supplies and materials: millions of bricks, millions of board feet of lumber, hundreds of miles of pipe, and mountains of sand and stone and cement for the two big concrete-mixing mills.

They set up their forms, which they called Trojan horses, built their towers for hoisting concrete, and started feeding sand and cement and stone to their mixing mills. These huge monsters take whole carloads of the stuff, whirl it around in their innards until it is mixed as smooth as the flour for a cake, then pour the stuff out into transit-mix trucks. The trucks gulp in vast quantities of water, whirl the mixture around some more, and deliver it to the towers. It is hoisted to the top of the forms and carried out on runways for pouring.

After the concrete becomes hard, the forms are lowered and moved for a repeat performance. This goes on and on, day after day, night after night. At night the entire site becomes a dazzling array of thousands of floodlights, the hoisting towers loom up like grotesque chimneys, and everywhere you see thousands of workers and trucks, scores of cranes, endless lines of moving freight cars, all flickering in this sea of light under the heavens.

These forms that are spawning the plant are enormous; each is much bigger than a house. Yet they can be lowered and moved to new positions easily and quickly. In only eight minutes the men can have a form ready for pouring another section of the

factory. They move it on wheels about the size of those on old dump carts. The wheels roll on tracks and the entire operation becomes a routine thing of moving forms and pouring. It seems to become so simple that you feel they could keep on building the plant all the way across the country if they wanted to. They don't use just a half dozen or so of the forms, but more than 50 of them, all busily laying a plant across some 80-odd acres of prairie.

The job devoured concrete in vast quantities, enough to completely fill a building 100 feet square and higher than the world's highest building. But all the figures are huge and quite beyond the understanding of most men. The important thing is that they built the plant in about a year and that it was capable of turning out every month enough aircraft engines to produce four times the power generated by Boulder Dam.

9

Mystery Buildings

Many strange buildings grew up out of the earth. Some were gigantic sausage-like affairs built of steel, others had walls two feet and more thick, one contained two channels of water more than a half mile long. All were built as fast as was humanly possible, and all performed deadly functions. You might call them the laboratories of death. For their job was to test planes and naval vessels and all kinds of weapons.

One of these laboratory buildings was built with two parallel ship-testing basins, an extremely difficult construction job which required that foundations and tracks for the towing equipment follow the curvature of the earth. This had to be done so that the towing carriages would pull the ships through the water parallel to its surface. The surface, of course, would be a slight arc because of the pull of gravity.

They avoided vibration in the towing carriages by making wheels and axles within tolerances of 1/5000 of an inch. These carriages were built to travel at constant speeds, even to within 1/1000 mile per hour. Another device is so accurate that it measures to within 1/20,000 of an inch. The whole job reminds one of building an exceedingly delicate and precise timepiece rather than two concrete basins.

Several years before the war contractors built test basins 1,800 feet long, 52 feet wide and about 22 feet deep. But when war broke over us and there was need for developing faster ships,

it soon became obvious they'd have to increase the length to 3,000 feet.

In these channels, the Navy placed ship models and pulled them at various speeds. In the process they were able to determine how a full-size ship would behave, the amount of power it would take to do the job, the way she'd act in a rough sea, how easily and quickly she'd turn and maneuver. When they were through studying a model they knew pretty nearly everything about her, from the way she'd rock a sailor to sleep to how she'd tremble and shake when spitting several tons of steel out of her big guns.

They tested a lot more than ship design. The Navy wanted to find out all it possibly could about the effectiveness of various mine-sweeping devices, torpedoes, and just about everything else that moves through water.

Beside the testing basins they built variable-pressure water tunnels in which the experts could dunk a propeller and study its weak and strong points, a special circulating-water channel for studying the effect of currents on antisubmarine nets, mines, and other devices, a transparent wall tank into which they could peer and study the trajectories of all types of underwater projectiles. But perhaps the most interesting of all facilities is the pond used for testing the effect of underwater explosions on ship models, and how model torpedoes and bombs behave after they hit the water.

In addition to building an experiment station for testing battleships, torpedoes, bombs and other murderous gadgets, contractors built a number of queer-looking buildings, some of which reminded you of huge doughnuts pulled out into an oval. In these misfits among buildings you could press a button and view a wind storm that would make your ordinary hurricane look like a spring breeze. And that's what they were for: to create

winds so violent that they'd approximate the speed of an airplane. In some of the smaller tunnels in these plants, air is made to travel with the speed of a bullet.

These wind tunnels were used by experts to study the behavior of war planes under various conditions of speed, altitude, and temperature. In the bigger tunnels complete full-size planes can be tested; in others, parts of plane assemblies and models are tested. The planes or parts, of course, remain stationary as the blast of wind flows about them at a speed approximating the speed of a plane. Instruments measure the wind resistance of the plane and its components, such as the wings and cowling.

The wind tunnels vary in diameter from about a foot to more than 150 feet. In some, such as the altitude wind tunnel, it takes about 50,000 horsepower to operate the mechanism. This tunnel creates the atmospheric and temperature conditions that are found 50,000 feet above the earth. It blows wind through its fans at the rate of 500 miles per hour; and contains the world's biggest refrigeration plant with a capacity equivalent to 20,000 pounds of ice daily, enough to drive the temperature down to 48 degrees below zero.

Another tunnel, called the icing research tunnel, which is a part of this same big laboratory in the Middle West, is used to investigate flight characteristics of propeller power plants and plane components under icing conditions. Here they can make rain, can blow air through at 400 miles an hour, and can reduce the temperature to 60 below.

On the West Coast they built the world's largest wind plant. As high as a seventeen-story building and looping out over eight acres, it varies in cross section from an oval 40 by 80 feet, where entire planes can be tested, to a passage 133 feet wide and 173 feet high. To make the hurricane—air is blown through this gigantic steel tube at more than 200 miles an hour—they erected

six enormous fans, each with a diameter equal to the height of a four-story building and each driven by a 6,000-horsepower electric motor.

Constructing this enormous steel tube bent into the shape of an elongated doughnut was mostly a matter of fitting and riveting and welding together thousands of pieces of steel varying in weight from a few hundred pounds to 50 tons and more. All in all, they jockeyed into place and put together some 12,000 tons of fabricated steel; used nearly 2,000 sheets of detailed drawings.

These and hundreds of other exceedingly complex jobs were needed in a hurry. With them we could improve our weapons, increase the effectiveness of our armed forces. They were not huge, spectacular construction projects, but they were an all-important gear in the war machine.

10

1,400 Miles Underground

THOSE tank stabs across Africa and Europe, those 1,000-plane raids, were made possible by an infinite number of closely coordinated factors, varying from the little girl who salvaged tin cans to the construction of great synthetic-rubber, aluminum, magnesium, steel and other plants. But they also were made possible by our ability to produce and transport vast quantities of oil in the face of submarine attacks off our East Coast.

The problem was to get oil from the fields of the Southwest and West to East Coast ports. We didn't have enough tankers to haul it over the dangerous water route through the Gulf and on up the coast, and we didn't have enough tank cars to transport it by rail. So we built the biggest and longest pipe line in the world. Then we built another almost as big.

Both "Big Inch" and "Little Big Inch," one 24 inches in diameter and the other 20 inches, were driven through under all kinds of obstacles: we didn't have enough steel, man power was short, equipment hard to get, existing machinery couldn't handle the big pipe, often the terrain was about as tough as any in the world, and the climate varied all the way from sweltering heat to below zero cold. Yet we built the lines in record time.

In the biggest of these miniature subways an endless stream of crude oil flowed like blood in some giant artery from Longview, Texas, to Phoenixville Junction, Pennsylvania, a distance of 1,254 miles; smaller feeder and distribution lines bring the total to 1,476 miles. "Little Big Inch," the oil-products line, starts at

Beaumont, Texas, and ends at Linden, New Jersey, 1,475 miles away. Its network of feeder and distribution lines adds some 231 miles, making the total length of pipe laid 1,706 miles.

Both lines cut through eastern Texas, snake their way through eastern Arkansas and come together at Little Rock. From there they follow the same route, shooting northeast through northern Arkansas and southeastern Missouri on up to Norris City, Illinois. They burrow under southern Indiana and Ohio, touch the northern tip of West Virginia, and run across southern Pennsylvania on into Phoenixville Junction, Pennsylvania, and Linden, New Jersey.

Over this long route, oil flowed in "Big Inch" at the rate of 4½ miles an hour, arriving at East Coast points about 12½ days after leaving Longview, Texas. Although this seems like about the speed of molasses, the rated daily throughput of the line is equivalent to 19 or 20 trainloads of 75 cars each. It would take a pool of 21,000 tank cars to move this much oil from Longview to New York daily and at least 240 locomotives and train crews would be needed to move the empty and the loaded trains continuously.

In building these two lines, contractors welded together 645,000 tons of steel pipe, or 21,185 carloads. For "Big Inch" alone they put to bed 1,254 miles of seamless steel tube 24 inches in diameter. They dozed out the right-of-way, ran in their big trenching machines, and hauled pipe back from rail points to the line. When the going was good, their trenching machines walked along at the rate of 12 feet a minute, eating out a trench 4½ feet deep and 34 inches wide. Across cotton patches, swamps, forests, up mountains, they went, a veritable army of clumsy, waddling machines, their great steel teeth biting into the earth, a constant stream of earth pouring out their chutes—eating out a ditch through 11 states and 95 counties.

Sometimes they had to go through miles and miles of granite. Their trenchers couldn't even bite, so they used three sticks of dynamite every three feet and blasted their way through.

When they hit swampy bottom-lands they struggled through bottomless mud. Their equipment almost sank out of sight, their dozers stalled, but they corduroyed their roads and right-of-way and somehow kept going. In one place they corduroyed 14 times to get their equipment and pipe in. In some places they dragged in their trucks behind tractors, in other places they lugged in sections of pipe, or joints, weighing about two tons and forty feet long, on the side booms of their big D-8 "cats." Up in the Allegheny Mountains they winched their heavy equipment and loaded trucks uphill, snubbed them downhill.

Often they had to bend the pipe to fit curves and dips and sharp grades. Both hot and cold bends were made, depending on circumstances. The cold bends were made with a bending rack and two or three of their big tractors. Hot bends were made by heating parts of the pipe to a cherry red with a special blowtorch and then bending with tractors.

They strung out their pipe beside the ditch and sent human swabs scurrying through each joint. These men got down on their bellies and rode a scooter through the pipe, cleaning out debris and chasing out small animals, such as chipmunks, rabbits, squirrels and snakes. Then they lined up their pipe, welded the joints together and rode their cleaning and priming machines over the sections. These self-propelled machines ride on top of the pipe at a speed of about 40 feet a minute and whirl a series of wire brushes about it, removing all rust, mill scale and dirt. The brushes are followed by shoes which coat the pipe with a coal-tar primer.

Now the pipe is ready for the coating and wrapping machine, a queer looking contraption with two stubby steel arms, one hold-

ing a roll of asbestos felt. As the machine rides on top of the pipe it first spreads a heavy coating of coal-tar dope. Then come the two steel arms which whirl around the pipe and wrap the felt in a spiral about it. It is the most colorful of all pipeline machines. You see it riding the long steel tube—sputtering, pouring out dope, its crazy arms spinning around and around like some strange bug making a gigantic soda straw.

The next job is to lift the welded sections of pipe and lower them into the trench. The workers rumble up with their "cats," which carry short booms on one side and a series of counterweights on the other. The arms of their "cats" swing out over the tube. They start lifting several tons of pipe, the "cats" rocking over on their sides. Slowly the big tube is swung over the ditch, lowered, and gently put to bed. Finally they push dirt on their sleeping baby, their draglines swing out and scoop up dirt, their dozers spit and push rolls of dirt over the pipe.

When they hit river crossings—and they crossed more than thirty rivers, including the Red River, the Arkansas, the Mississippi, the Ohio, and the Susquehanna—they often blasted ditches in the stream beds, good deep ditches to hold their pipe in place. They brought in their dredges, both suction and clamshell. Soon you'd see the jaws of the clamshells plopping into the water—falling wide open like dangling steel spiders, rising out of the water dripping and with great mouthfuls of rock and muck. All the time the engines are puffing and panting, and gasping out black smoke.

In preparing the pipe for these crossings, they put on extra heavy layers of "dope" and asbestos felt, fasten wooden slats about the tube, and whitewash the whole thing so that it can be seen under water. They keep the empty tube in the trench on the river bed by weighing it down with enormous cast-iron sleeves.

They use two to four sleeves for the small streams, on wider crossings they put them on at about 34-foot intervals. And they always lay their pipe with an upstream bend so that it will have more strength.

Sometimes, while they were working, the rivers would rise suddenly and sweep away their pipeline, barges, dredges and other craft. Then they'd start in again, fighting to finish the job before another flood struck and twisted off their pipe. Their first battle with floods and swirling currents occurred on December 29, 1942, while they were pushing their line across the Mississippi. The sudden rise smashed their barges and dredges, reached down and snapped off some 600 feet of pipe. But they replaced the pipe before gate valves and other equipment for the line arrived and there was no delay in operation because of the flood.

Again, during May, floods lashed out along the Arkansas and Mississippi. On the Mississippi the strong current whipped about a towboat pulling a string of loaded barges, and smashed boat and barges against their equipment. All their mooring cables snapped, and the stream tore out several hundred feet of spare pipe then under construction. But the original 24-inch pipeline held.

Their toughest fight against flood was below Little Rock. On May 17, the Arkansas River, swollen and racing, lashed out over its banks and cut an entirely new channel 35 feet deep and about a half mile wide. It cut under their 24-inch pipe and left it suspended. The rushing current hit it and broke it in two places. Oil gushed out of the pipe, but they closed the line with their big valves and only a little oil was lost. Then began the race to lay pipe and get oil across the river. The river was whipping about too savagely to permit attempting a crossing at the old location,

so they ran a temporary 20-inch emergency line 8 miles long up to and over the Rock Island Railroad Bridge at Little Rock. Night and day their big "cats" yanked pipe around and their trailer trucks grunted over the country roads. They did the job in less than a week; in less than a week they were pumping oil across the river.

Maybe you believe that except for the battle against floods, the construction job was a leisurely affair, like any normal peacetime job. It wasn't that way at all. Behind it and driving the workers on was a desperate urgency. Our armies had to have more and more oil. The prospect for fuel oil was far from encouraging. Essential transportation in many a city was jeopardized.

The vital importance of the lines is indicated, perhaps most clearly, by our need for high-octane gasoline. Before the war, in May 1941, we had 16 plants equipped to turn out this superfuel, by the end of 1945 we had 73 plants, and during March of that same year we were turning out 525,000 barrels a day, more than a thousand times as much as we were making before the war.

When the war began, the standard fuel was 87-octane gasoline. Compared with this fuel, 100-octane reduced the take-off distance of planes by 16 per cent, boosted the ceiling some 27 per cent, enabled our planes to climb 40 per cent faster, and gave them ability to carry about 43 per cent more cargo. Such advantages helped us in our carrier-based operations and enabled us to use captured airfields quickly. With 100-octane gas, a plane could dump seven tons of bombs on Tokyo instead of five; and our fighter pilots could get in the air quicker, climb higher—which fact, in an emergency, might well mean the difference between life and death.

Some 400 plants provided the base stock used in making high-

octane. This stock had to be transported to many points for processing, then the finished product had to be hauled over to the fighting fronts. "Big Inch" and "Little Big Inch" helped us do the transportation job.

In addition to high-octane aviation gas, fuel oil and automotive gas, petroleum provided raw materials used in the manufacture of an almost infinite variety of products such as synthetic rubber, plastics, paints and varnishes, alcohols and solvents, and explosives. And there were the vital lubricating oils, natural gas, and so forth, all vital to the war program.

Of course, "Big Inch" and "Little Big Inch" weren't the only pipelines used to speed oil eastward. Even before the war we had 127,000 miles of pipelines, enough to go around the earth at the equator five times. This system, spread out under the earth like a thousand arteries, was augmented during the war by 33 major oil-line projects, 9,800 miles, about two-thirds built with new pipe, one-third with the secondhand pipe we tore out of the earth.

Besides building new lines, we reversed the flow in some of the old ones, pumping oil from west to east instead of from east to west. In other lines we installed more and bigger pumps so that the rate of flow was stepped up. We built loops to increase the capacity of some lines, turned out more tank cars, and built more and faster ocean-going tankers to get the stuff to Eisenhower. At the same time we built huge cracking plants, synthetic-rubber plants and others to turn oil buried miles under the earth into weapons and fuels and lubricants. Into these plants we poured crude oil and petroleum products. Out of them came plenty of the hard muscle we needed for the knock-out punches.

The rated yearly throughput of the two lines—"Big Inch" for crude and "Little Big Inch" for petroleum products—was

195 million barrels or more than 8 billion gallons, enough to fill 815,000 tank cars. From the time oil first started flowing through "Big Inch" until March 1, 1944, the line poured out 97 million barrels, or enough to float, on a displacement basis, 1,200 Victory ships.

11

We Hatch Two Eggs

THE fate of the world seemed to hang on the secret of the smallest known particle of matter. The race in perfecting a lethal weapon from fission of the atom led to the creation almost overnight of complete cities, and some of the largest and most expensive industrial plants ever constructed. There was one all-important question: how soon could we make these instruments of sudden death? For to make them required incredibly large and intricate plants. Indeed, when you look back over those construction feats at Oak Ridge and Hanford and Los Alamos, they seem almost as fantastic as the bomb itself.

Take, for instance, the building of a city bigger than Portland, Maine, or Cedar Rapids, Iowa, or Galveston, Texas. Take the buildings with concrete roofs three feet thick, walls to protect workers against lethal rays, the winding of magnets with 14,000 tons of silver, and the erection of a building a half-mile long and a quarter-mile wide. Then throw in such items as a special membrane containing pores two-millionths of an inch in diameter—not just a few hundred yards of it, but enough to reach from New York to Tokyo—the 15,000 valves and 50 miles of nickel tubing in one plant, the 20,000 pages of specifications and 12,000 drawings used in another plant, and you have some idea why the history of the building of these vast hatcheries of death is like a story from Mars.

Yet the plants were built. They were strange affairs, and they were shrouded in mystery, even though more than a hundred

thousand persons worked on their construction. They were built in record time—built in spite of all kinds of obstacles that were encountered in types of construction never before attempted, in the difficulties in securing the tremendous quantities of scarce materials needed, and in the necessity for the closest possible secrecy.

Our scientists knew that six processes could be developed for making the "goo" in the bomb—the material that could be made to create explosions of such terrific force that a single bomb would wipe out an entire city. They also knew that with such a variety of processes available, it was likely that the Germans would soon come up with at least one process capable of doing the trick.

Many thought the bomb was the secret weapon Hitler kept promising his infantry and air force. If his method proved faster and more effective than any one of the six we might select, we could very well lose the war. That was why we could not afford to take chances, why we built plants, almost simultaneously, for all six processes. Only in this way could we be sure. Even then, the Nazi might beat us to it. Because of this, the atomic-bomb projects became the most desperate of all races against time.

One of the plants was built on 400,000 acres in the sand and sagebrush country around Hanford, Washington. This area was almost a perfect site. An abundant supply of pure, clean water was provided by the Columbia River for the uranium isotope process which drank up incredibly large quantities of it. There was plenty of electric power from the Bonneville Power Administration, and as only a small strip along the river was tilled, very little agricultural land was taken out of production.

In doing the construction job, contractors built the equivalent of more than seven huge industrial plants at a cost of $350,000,000. They rolled in their dozers and cranes and trucks in early June, 1943, and started turning sagebrush and sand into an atom

factory. They erected warehouses for miles of freight cars full of materials, threw together housing for some 40,000 construction workers, and built a small city for the men and women who would operate the completed plants. During the peak construction period, they transported workers in 900 buses with a total seating capacity of more than 30,000.

For weeks, trains from all parts of the country brought in the heavier, slower-moving equipment; trucks groaned through mountain passes with materials; trailers and jalopies loaded with workers jammed the highways. Into this area around the town of Hanford poured 1,900 dump and flat-bed trucks, 437 crawler tractors, 311 crawler cranes, 44 railroad locomotives and 450 railroad cars, and thousands of other units, including 1,800 road vehicles.

Then they started to dig. No one knew precisely why, only that it was hush-hush and big and mysterious. Probably it had something to do with the war, maybe a plant was to be built to make planes as big as battleships, maybe to turn out secret death rays, or maybe to make tanks that would fly. No one thought of such a crazy Buck Rogers idea as an atomic bomb. But whatever it was, it was needed in a hurry.

The size of the job was bewildering. There was a feeling of bigness and urgency in the air. Every morning you heard the bulldozers warming up, sputtering and snorting as they moved out for their first run; if you traveled about, you saw not a few or a dozen, but hundreds of them—all pushing streams of dirt before them, their heavy blades gleaming in the sun. You saw the endless lines of trucks hauling dirt, the booms of caterpillar cranes swinging through the air, the cement-mixing plants devouring hundreds of tons of sand and cement and gravel and water, and then spitting out the wet mixture through pipes that delivered concrete to where it was needed.

As the walls and roofs of some of the buildings had to be several feet thick to shield operators of the plant from radio-active rays, a lot of concrete was used. All in all, they poured 780,000 cubic yards of it—a little more than 100,000 cubic yards for each of the six buildings—enough to build a solid concrete wall one foot wide and six feet high and 660 miles long.

In one building, they had the job of constructing a concrete roof three feet thick. This roof was 800 feet long and 60 feet wide with no intermediate support between the walls. For a while it looked as though they'd have to build an unusually strong form on which to pour their concrete and extend the thing the whole length of the building—an expensive and laborious operation requiring more time than they could afford.

Then someone hit on the idea of building a huge traveling form, much like those used in lining tunnels. They built it and ran it on tracks that had been installed for cranes near the tops of the walls. It worked beautifully. They put the contraption on the rails, jacked it into position, then poured their concrete. After the concrete was hard, they lowered the form by turning the jacks, ran the whole thing down the line a little, and repeated the operation until the entire length of 800 feet had been poured and set. They built three buildings of this type, using the same set of forms on all three.

In building their main building and their 386 miles of highways and 158 miles of railroads, they dug and pushed around prodigious quantities of dirt—some 25 million cubic yards of it. That much dirt is hard to visualize; but if you loaded it on average-size trucks used for dirt moving, you'd have 5 million truckloads. That many trucks, running six feet apart, would make a caravan more than 25,000 miles long—long enough to reach clear around the earth at the Equator. But you couldn't, of

course, get 5 million trucks, for there aren't that many in the country.

They used 270 grease and fuel trucks for servicing the equipment. They checked every piece of equipment at regular intervals—dump trucks after 250 miles or every three days, whichever was first, flat trucks every 500 miles or every five days, pick-up trucks every 750 miles or every ten days, etc. On the other hand, tractors and other heavy equipment were greased at the end of each shift.

But their really big job was at Oak Ridge for what was called the Clinton Engineer Works. Here they built plants capable of producing the explosive for atomic bombs by three different processes. Together with the city of Oak Ridge, which they built in record time, the plants and facilities cost $1 billion, a great deal more than the initial cost of any industrial plant anywhere else in the world.

This plant had to be safe from air attacks and not too close to centers of population, for an explosion might rock the surrounding area like an earthquake. It had to have dependable electric power in big quantities, and the site had to be flat enough for building areas, yet divided by hills or natural barriers, so that destruction of one part of the plant would not sweep through the other units. Also the area should provide a site of 5,000 acres for a city which would have a population of 75,000 persons, be convenient to rail and bus transportation, and have an ample supply of water. They located such an area along the Clinch River, a little way downstream from Norris Dam and about 18 miles east of Knoxville, Tenn. All in all, there were 59,000 acres of submarginal land cut by a series of ridges.

The first problem was to get the men and materials and equipment, to get them in the teeth of war scarcities, and to get them

promptly and in tremendous quantities. All over the country they interviewed workers, investigating thoroughly the backgrounds of 400,000 men and women, and selecting about one in every three for the job of building one of the plants and the city of Oak Ridge.

Materials, which were scarce as hen's teeth, were obtained under a blanket of secrecy. The full strength of the Federal Government was thrown behind the job and, when necessary, priority ratings up to AAA were granted. The biggest single purchase was $17,500,000. But even this was peanuts compared to the $400,000,000 worth of silver, 14,000 tons of it, they borrowed from the United States Treasury to substitute for scarce copper in making bus bars and winding coils for hundreds of magnets.

And when it came to construction equipment, they solved part of their problem by getting 500 pieces from various government projects that had been completed or closed down.

As soon as they solved one problem, they had to find the answers to dozens more. The bigness of the undertaking was without precedent. There were no hard and fast rules to go by. Distribution of materials, for example, although often a construction problem, suddenly became a nightmare on a job this size. Carloads rumbled down their sidings in unexpected numbers, their contents often unsolicited, their use in the project unknown. They threw up more and more warehouses, laid more track. Materials poured in at the rate of some 500 cars a week. But they flooded the area with light, threw in night shifts, and except for one short period managed to keep abreast with the unloading and storing job.

Some of the cars were packed with secret equipment. No one, except a select few, knew what the sealed cases contained. Spe-

cial warehouses had to be built for this equipment and it could not be unpacked except on the spot where it would be installed. And although no one was conscious of it, everyone on the job from the highest executive to the humblest pick-and-shovel man, from the scientist in his laboratory to the engineer at a drafting board, was under the close surveillance of FBI men. The eyes and ears of Uncle Sam were always near.

The biggest of the great plants built in the area was for the separation of the isotope U-235 from uranium by what is known technically as the gaseous-diffusion method. The other two plants used other processes, the electromagnetic method and the thermal-diffusion method. All three processes are extremely complex.

The plant for the gaseous-diffusion process contained a great U-shaped building over a half mile long and almost a quarter mile wide. This huge horseshoe, along with other buildings in the plant, required miles of blueprint paper, thousands of draftsmen to make the 12,000 drawings required. The specifications alone covered 20,000 pages, equivalent to 100 volumes of 200 pages each. Operating instructions would have filled 50 such volumes.

The U-shaped building sprawls over 60 acres, an area equal to that of a small farm. There are four floors in this monster. The construction is of reinforced concrete up to the main floor, of steel and asbestos-cement siding from there on up.

This incubator for the most potent eggs ever made, for bombs that can disintegrate entire cities, is packed with some of the strangest equipment you ever saw. There is, for instance, the previously mentioned special membrane long enough to reach from New York to Tokyo and containing pores averaging about two-millionths of an inch in diameter. There are millions of these pores per square inch of membrane and through them is bounced

U-235, separating it from U-238. Both are parts of the uranium atom. Some idea of the size of U-235 is indicated by the fact that it takes about a half million of them to equal the thickness of a human hair.

Some of the equipment involved nearly 1,000 miles of air-tight welding. If it were possible to put it all end to end and you started out to walk beside it, you'd have to walk more than a month to get from one end to the other. And that's not all, the entrails of the monster contain 3,800 miles of electrical conductors and 825 miles of electrical conduit. In addition, when they installed the thousands of precision instruments they put in four million feet of copper tubing and three million feet of copper wire.

Besides this building there are many others. They built the world's largest air-drying installation, and a spray-cooling tower capable of handling enough water for a city the size of Chicago.

In addition, there's the town of Oak Ridge where the atom makers live. It's not just a pleasant little country town of a few hundred homes, but a bustling city of almost 75,000—about the size of Portland, Maine, or Galveston, Texas. Its claim to fame is that it's the home of the atom bomb and that it was pushed up out of its wooded site on the ridge in 30 months.

They built it in the same big way they did the atom factories. It was like an entire city rolling off some huge assembly line—homes, hospitals, schools, churches, and all the rest.

Some of the homes were built in sections in distant plants and trucked to the site. These sections were complete units in themselves. Maybe one section would contain the living room and kitchen and bath, all complete with plumbing and wiring and built-in furniture; another section would contain two bedrooms, and still another section another bedroom. When they rolled up on trucks to their waiting foundations, cat-cranes stretched out

their arms and gently lifted them from the trucks. Then men hooked up the sections and families could move in.

They turned out other houses in the form of a series of prefabricated panels, roof trusses, floor sections, etc.; then they trucked them to the site and hooked them together. Roofing, always a problem in home construction, was made of lapped sections of insulation board, encased with 90 lb. mineral-surface roofing, thus providing sheathing and insulation and roofing in a single unit; all you had to do was to nail the sheets on the rafters.

They brought in their bulldozers and scrapers, and sliced out 100 miles of roads, which wound about the ridge and on down into the valley. Trench diggers ate out trenches three feet deep for their water mains. They put in sewer lines, stuck in poles for electric and telephone lines. They did this for a city spreading out along a ridge, one-and-a-half miles wide and six-and-a-half miles long.

They threw up hundreds of quonset huts—those queer-looking affairs with semi-circular arches used by the Army and the Navy. They built homes, barracks, apartment houses, a trailer park, just about every kind of living quarters.

They also built nine schools, several churches, a 300-bed hospital, several large cafeterias, two big laundries, a cold-storage building, and two large groups of warehouses. They turned out two main shopping centers with plenty of parking space and a good many neighborhood-store groups.

Still, they weren't through. They built places where people could play and relax: 22 tennis courts, several recreation buildings and bowling alleys, two roller-skating rinks, a good many soft-ball diamonds, two baseball diamonds, badminton courts, seven theaters, and a library. There were dozens of playgrounds and wading pools, and a big swimming pool near the center of town.

Now you'd think the contractors could call it a day. But no, there was still work to do. The Army asked one of the contractors to help run the town. So that firm operated the cafeterias, the hospitals, the movie theaters, laundries and the bus service. It ran the fire and police service, operated a rental and maintenance service, in fact, performed all the functions of a public-utility department for the city.

And when their giant incubator hatched its first deadly egg, when for the first time it lay gleaming in the sun, imprisoned in its steel body were the spirit and sweat of a free people. On August 6, 1945, it plummeted down from the belly of a B-29 over Hiroshima and burst with a blinding, searing, earthshaking blast that tore the entire city asunder. The terrific explosion represented not only the work of a few hundred scientists or engineers or brass hats, but also the very heart of America, her men and women and children, from the lowest-paid laborer on the construction job to a very tired man with steel braces on his legs who once sat in the White House.

12

Island Forts in the Atlantic

IN THE Atlantic we built bases from Greenland and Labrador to Trinidad and British Guiana. We built them on glacial ice thousands of feet thick and we tore them out of the jungles of South America. We fought heat and cold and distance and hurricanes and enemy submarines, but we built them. From many of them our planes swarmed out across the Atlantic to the British Isles, Africa and points east. Some flew across Africa to the Red Sea, India, Burma, and China; others flew to North Africa to fight the Germans and Italians in Libya and Tunis.

Not only were a number of these bases the springboards that enabled us to hurl fighter planes, bombers, and cargo ships around the world, but some of them also protected the approaches to the Caribbean and the Panama Canal. For on the chain of islands swinging down from Florida to Trinidad we built an elaborate system of bases—on Nassau, the British West Indies, Puerto Rico, Cuba, Trinidad, British Guiana, and in other strategic locations. From them we could cover the Caribbean with an umbrella of planes, strike enemy vessels far out in the Atlantic.

One of the largest bases was on Puerto Rico at Borinquen Field, about five miles north of the town of Aguadilla. This base, the most important in the Caribbean Area for training B-29 bomber crews and for servicing aircraft, was a major air transport station on the Florida-South America-Africa Route. We built a complete airfield with its runways, parking aprons, taxiways, lighting and repair facilities. We tossed up housing and

hangars and recreation buildings and scores of other structures.

Even Nassau, that delightful little tourist center, was flooded with construction workers. Here they lived the life of Riley at one of the most exclusive of all the resort hotels on the coral beaches. For once they had all the comforts of home and then some, a far cry from the usual bleak barracks, the rough pine tables, and the hard bunks on most construction jobs.

In the Bahamas most of the area of operation was thick with small pine trees and a dense tropical undergrowth. In clearing the sites, native labor was used, powerful blacks who hacked out the runway and dispersal areas with machetes. Later, bulldozers helped clear the way.

The cleared ground was as rough as the bed of a mountain stream, honeycombed with "banana holes," some of them unusually big. These holes, hollowed out by the action of the elements over thousands of years, were filled with soil. They salvaged the soil for future surface dressing, backfilled the holes, and broke up the entire surface with big rooters and dozers. Then sheep's-foot rollers, those heavy drum-like affairs studded with hundreds of thick spikes, were pulled over the area, mashing down the surface. The airfield was then brought to grade with scrapers and thousands of truckloads of fine-graded coral from nearby quarries. The coral was compacted with smooth rollers and topped with graded rock and asphalt.

One of their problems was the lack of fresh water for servicing the airfields. Although fresh water was on New Providence island it was difficult to obtain because of the coral, which, of course, is porous and saturated with salt water. Rain water floated on the salt water like cream on milk. But as soon as they attempted to skim off the fresh water it would become mixed with salt water. Local people had tried drawing it off with pumps and windmills, but every attempt had resulted in failure. Finally, the contractors

developed an ingenious method, using a series of open trenches some 300 feet long and 8 feet deep. Fresh water would seep into these trenches and perforated pipes suspended about a foot under the surface and running the full length of the trenches enabled them to draw off the fresh water by central pumps without disturbing the salt water underneath. Each 100 feet of trench drained about an acre of ground, and produced about 1,000 gallons a day.

Besides the airfields, they built hangars, barracks, fuel-storage tanks, and several hundred buildings for each of the two fields. Most of the buildings were of cement block; their roofs were anchored down so that hurricanes couldn't whip them off.

To the south, on Trinidad, we fought an annual rainfall of 120 inches, yanked our heavy equipment in with "cats," and carved an airfield out of jungle. Bulldozers pushing over trees and slicing out chunks of undergrowth, worked side by side with natives who hacked away jungle with cutlasses and machetes.

We brought down our own cement-pipe plant and made pipe for the drainage system. We hauled in a small army of heavy equipment: 115 tractors, 99 angles and bulldozers, 40 carryall scrapers, 30 cranes, 36 road pavers, 13 batching plants, 10 stone crushers, 44 cement mixers, 20 power shovels, 613 trucks, 98 railroad cars and locomotives, and other equipment, including 398 pumps. Against the jungle, dank and hot and tangled with undergrowth, we threw our army of mechanical earth-eaters, turned it into strips of concrete almost a mile long, into houses and tank farms and hangars and all the other facilities essential to the servicing of planes and crews.

Far from the jungles and steaming heat of the tropics, other construction workers were fighting the howling winds of the Arctic and temperatures that drove thermometers to 50, 60 and 70 degrees below. There it was so cold that, as one man said, your

breath froze into floating snowbanks and your spine into an icicle.

They tore into this north country—Newfoundland, Eastern Canada, Labrador, and Greenland—under secret orders from the War Department. In Newfoundland contractors built one airbase, facilities for two main garrisons, and 32 miscellaneous outposts and weather stations. In Eastern Canada and Labrador they cut out 7 airbases and tossed up 19 outposts and weather stations. And in Greenland they built 4 airbases and 14 outposts and weather stations.

The Greenland job, perhaps as interesting as any of these construction battles against snow and ice and freezing cold, was done close to the Arctic Circle. This island, more than three times as big as Texas, is 200 miles from Iceland, and 700 miles, via Iceland, from the British Isles.

It is a wild and tough country. Around its jagged coast cut into by thousands of fjords, many of them frozen solid or choked with ice, mountain barriers ripple like an enormous serpent. Some of the peaks soar to more than 10,000 feet, but most are from 2,000 to 4,000 feet high. This mountain wall of ice and rock and snow encircles the great icecap which sweeps over the horizon for more than 600,000 square miles and fills the deeper valleys with ice 10,000 feet thick. Over that trackless waste of snow and ice, cold and silent and ageless, polar winds sometimes scream and pile up snow 18 feet deep. It was barren and treacherous, and it lay before them in the bitter cold of the long arctic nights like a piece of eternity, a mysterious relic of countless ice ages, born millions of years before man first walked the earth.

Into this country they brought their bulldozers and cranes and power shovels and stone crushers. Most of their work was along the coasts and not on the icecap, but some of their jobs took them far north of the Arctic Circle. They worked in locations so inaccessible that at one camp Christmas presents did not

arrive until May and were brought in by Coast Guard cutter and dog sled. Their first mail in 100 days had to be flown in.

At one place a snow slide crushed in their living quarters and they had to face arctic cold without shelter. For a while it looked as if the entire group would be lost. Back at the base they frantically threw together packages of lumber six feet long, rushed them into Liberator bombers, and flew them to the half-frozen men. The Liberators circled the group, dropped the lumber from their bomb bays. Soon new buildings were rising out of the snow and ice.

All year round they worked on the airbases, even through the arctic nights. Often they built their barracks, hospitals and other buildings without eaves so that the wind could not get a finger-hold and tear off the roofs. They braced the structures against winds that sometimes whipped along at 170 miles an hour.

In pouring concrete abutments for 160-foot arches for supporting the roof of a hangar, they first heated the aggregate by running perforated steam lines under piles of the stuff. They used warm water in making concrete and poured it at a temperature above 70 degrees. Then to keep it from freezing they wrapped it with tarpaulins, ran in steam lines, turned on their airplane-engine preheaters.

In one place they were unable to obtain sand for the concrete, so they made it. Water from the glaciers had washed away all the sand in the vicinity, leaving large beds of gravel. They dumped the gravel into their stone crushers and chewed it down to tiny particles. Into one end of the machine went stone, out the other end poured sand.

Transportation was one of their toughest problems and they had to fight to bring in their supplies—steel, cement, lumber, dozers, power shovels, food, clothing, in fact everything except sand and gravel. The fjords near some of the sites were open only

three or four months; beaches were often studded with huge boulders which made landing operations exceedingly difficult; some of their boats were crushed by the ice; sometimes storms tore down on them and ripped out their temporary camps on the beaches. At one location, during the early construction period, they made cable anchorages by blasting out pits in solid rock and filling them with concrete. These shore anchors, equipped with 2½-inch steel bars and rings, were used when violent storms suddenly lashed out against their ships.

Getting their equipment and supplies to sites for weather stations was a grim battle against snow and ice and mountains. Often they had to drag their supplies up steep, snow-covered slopes, yank it through icy mountain passes. At times the arctic winds screamed down on them and the cold cut through them like a razor. At times the mountains and the icecap were wrapped in a cold silence and you could hear the snow crackling under your feet. Sometimes the sites were surrounded by floating ice. Yet one of their first jobs was to build roads over which to haul in building materials.

Of the four main bases, the one at Ikatek was the hardest to build. Snowfalls buried the equipment, blanketed the roads in deep drifts, smothered the camps. Much of the time the earth was frozen as solid as rock and, until they blasted the material loose, their big power shovels were useless. They had to work night and day to keep ahead of the shovels. Even then, the cold fell down on them and froze gravel and dirt solid in the trucks.

During March, water rushed down the mountain sides and flooded the site. In summer, the mud became so bad that during the warmer daylight hours they were unable to top their runway with gravel, so they hauled and dumped and spread gravel at night. To add to their troubles, tides as high as twelve feet made dock operations impossible for sea-going vessels.

When the four major airbases and the 14 outposts and weather stations were completed, the construction workers had built hundreds of all types of buildings in addition to concrete and asphalt runways for the airfields. There were hospitals, barracks, roads, docks, tank farms, hangars, warehouses, water systems, sewerage-disposal systems, electric-power installations, and scores of other facilities—a construction job running in the neighborhood of $55 million.

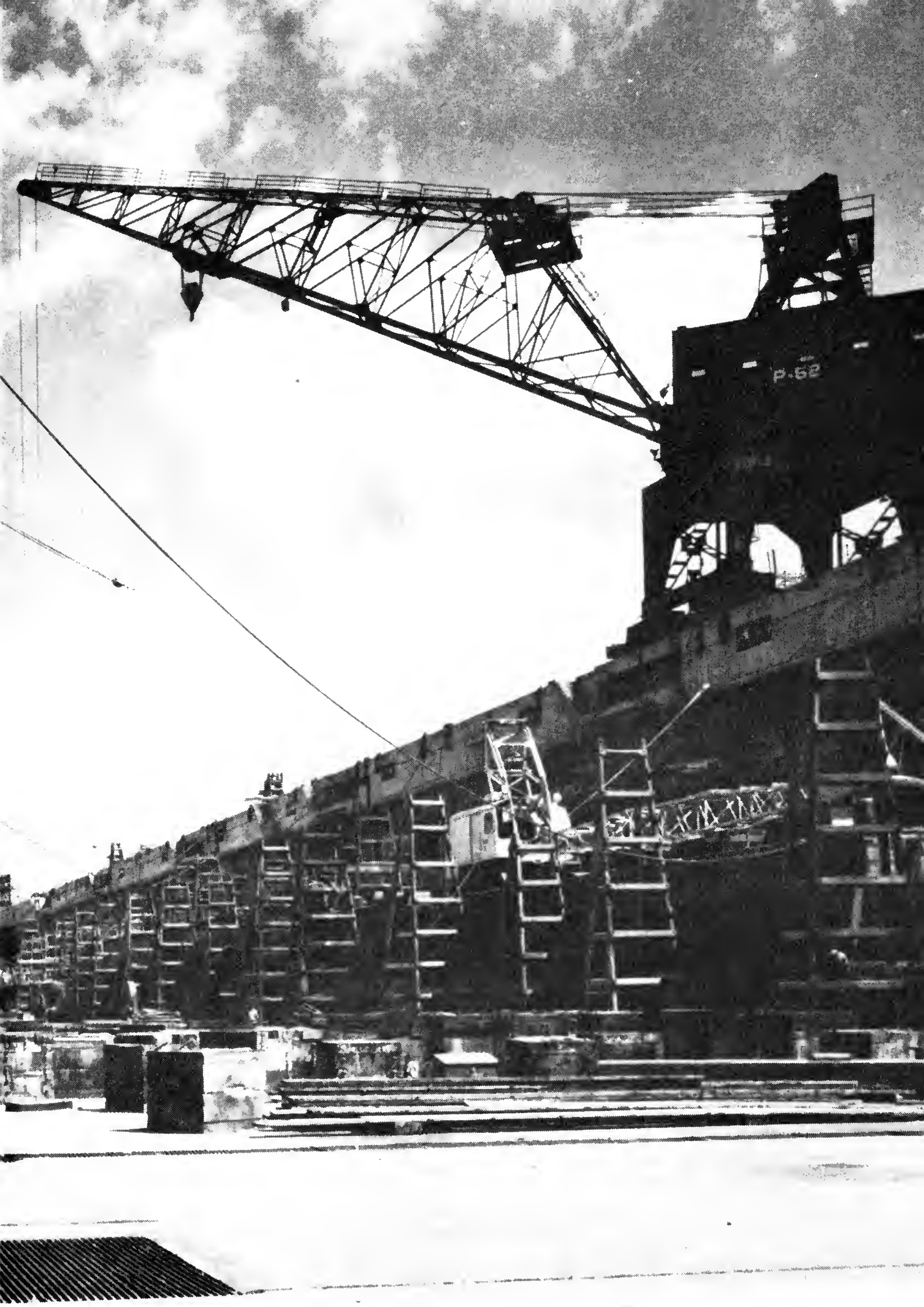
Although Greenland was not the biggest of our Atlantic bases—construction costs in the British West Indies approximated $127 million, in Newfoundland $76 million, and in Puerto Rico $70 million—still it was one of the most important. For more than a quarter of a century the Germans had realized its importance and had sent so-called scientific expeditions to explore the area. Before the war, they established weather and broadcasting stations in Greenland. From these stations the trapped *Scharnhorst* and *Gneisenau* received information that enabled them to slip away from the British fleet in a blanket of fog just 15 miles off the Dover coast.

"After the invasion of Denmark on 9 April, 1940," says the War Department, "it was recognized that the status of Greenland was of vital concern to the United States. The exposed position and vulnerability of Greenland might result in its being converted into a center of aggression against the United States. It was important to defend the Cryolite mines from foreign aggression or sabotage, and later it became essential for use in ferrying aircraft over the Northern route to the United Kingdom."

Cryolite was of the utmost importance to us, and Greenland and Siberia are the only two known sources of the compound so necessary in making aluminum. Unable to obtain it, the Germans had to use a synthetic substitute. The fact that we had it speeded up our production of the light metal and helped us to

turn out sufficient quantities for our fighter planes and bombers.

Building the Atlantic bases from Greenland to British Guiana and as far east as the Azores involved an expenditure of some 480 million dollars. It was a big job, filled with hazards, requiring long hauls through submarine-infested waters and back-breaking work under the heat of the Tropics and the cold of the Arctic, but it was just part of the over-all job of building bases clear around the world. These other jobs in the Pacific and the United Kingdom and Africa and Asia were also, in their own way, some of the finest engineering achievements of the war.



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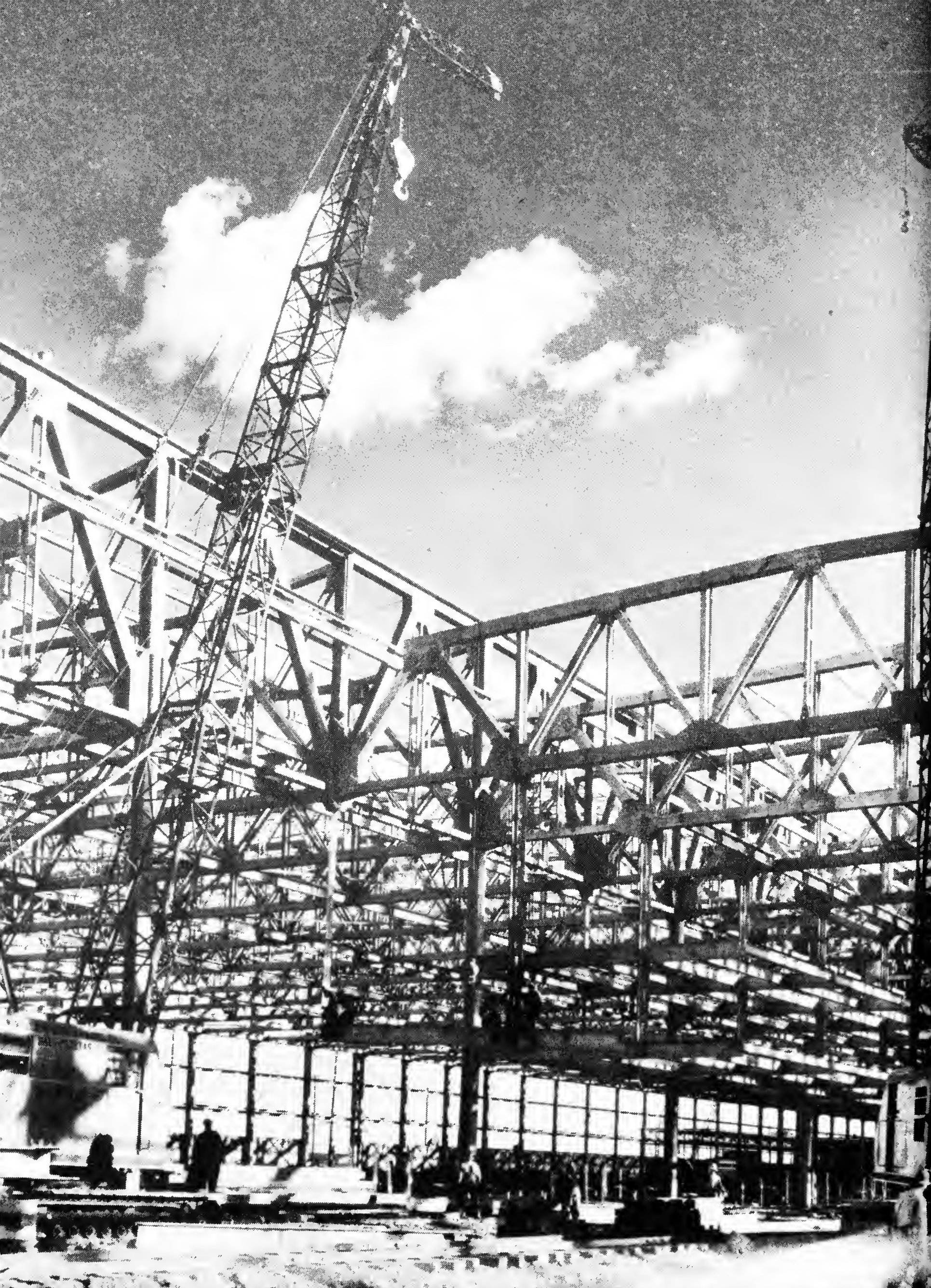
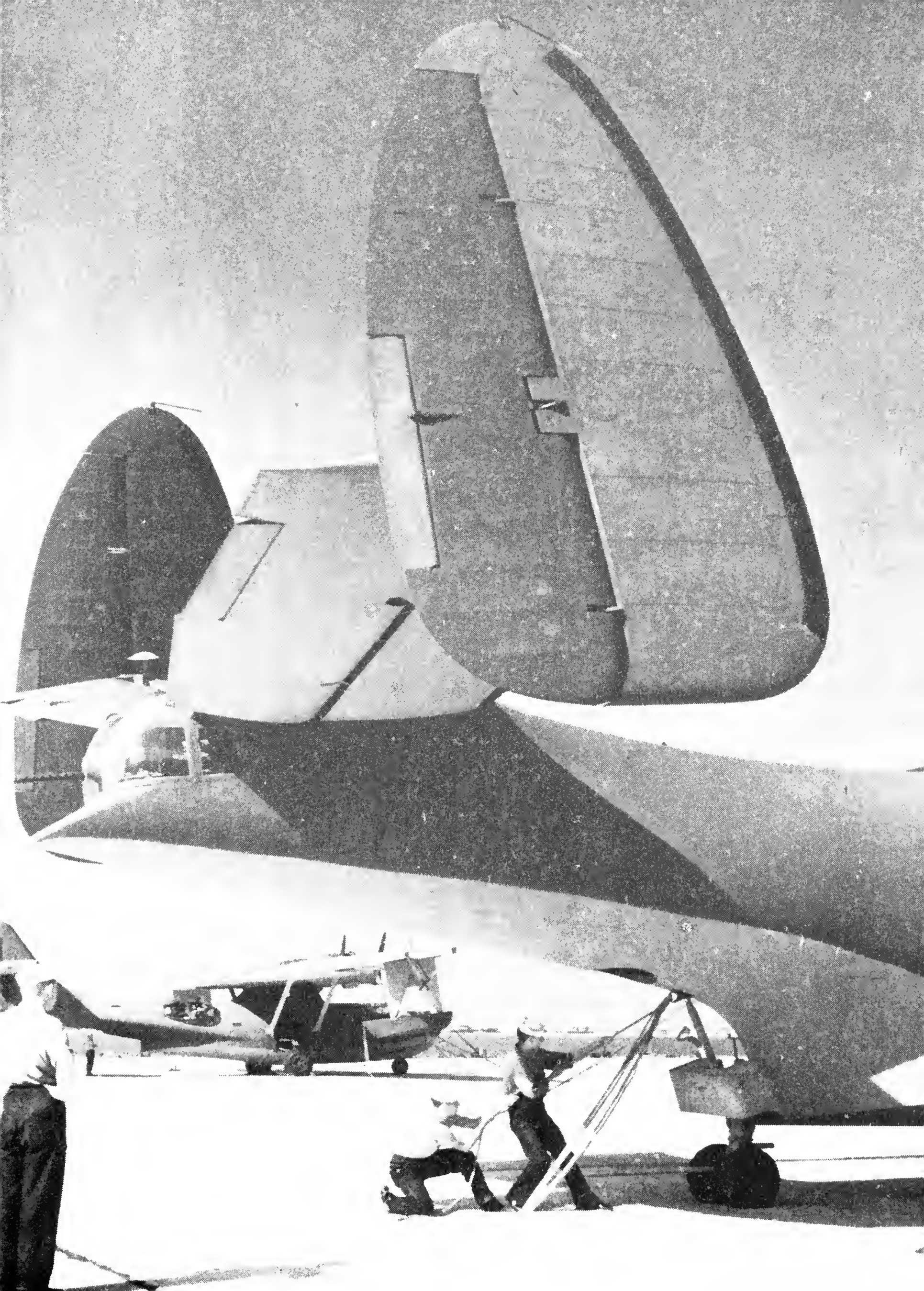
Workers at home dug out drydocks.



Bethlehem Steel Com

They built the aircraft plants . . .



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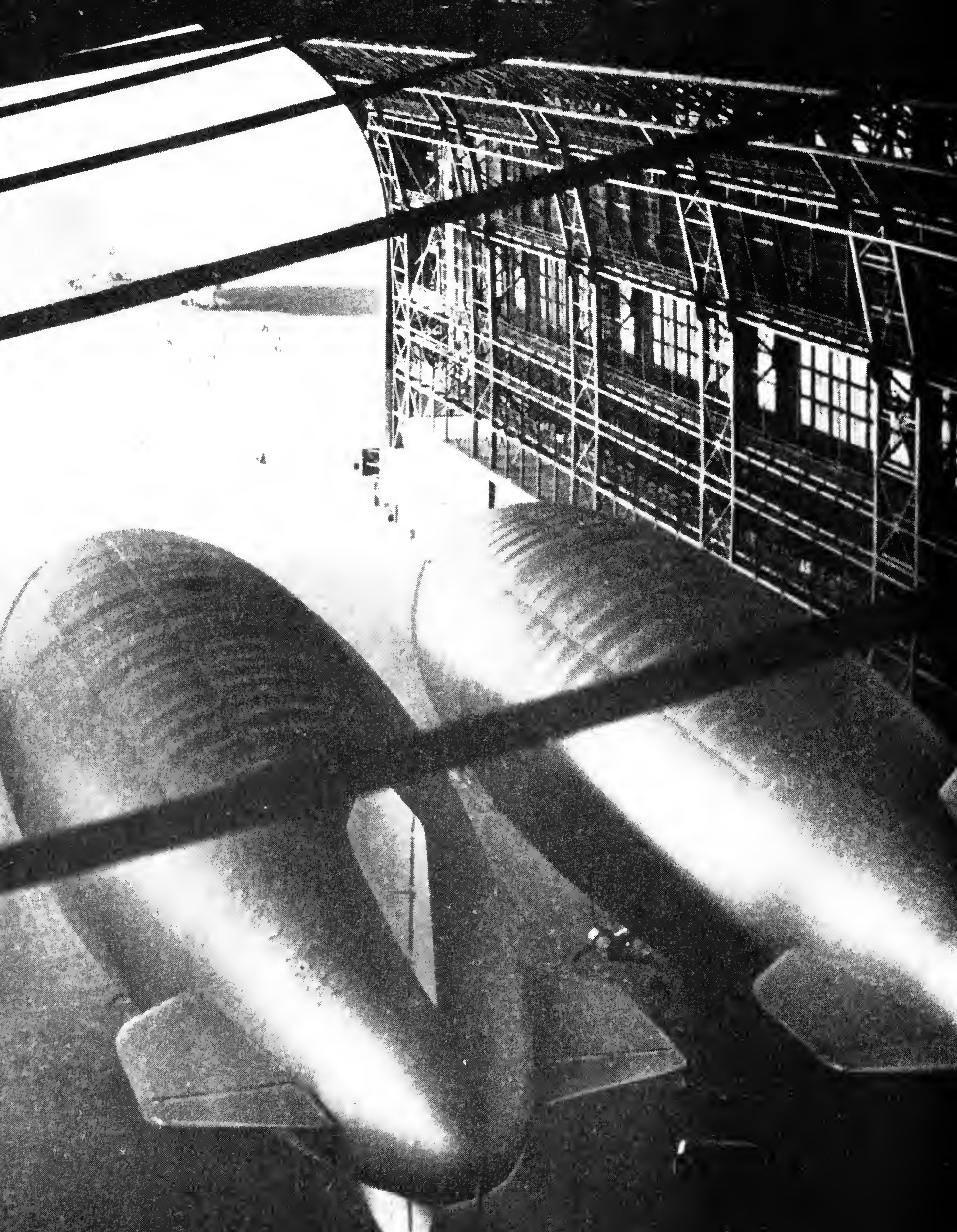

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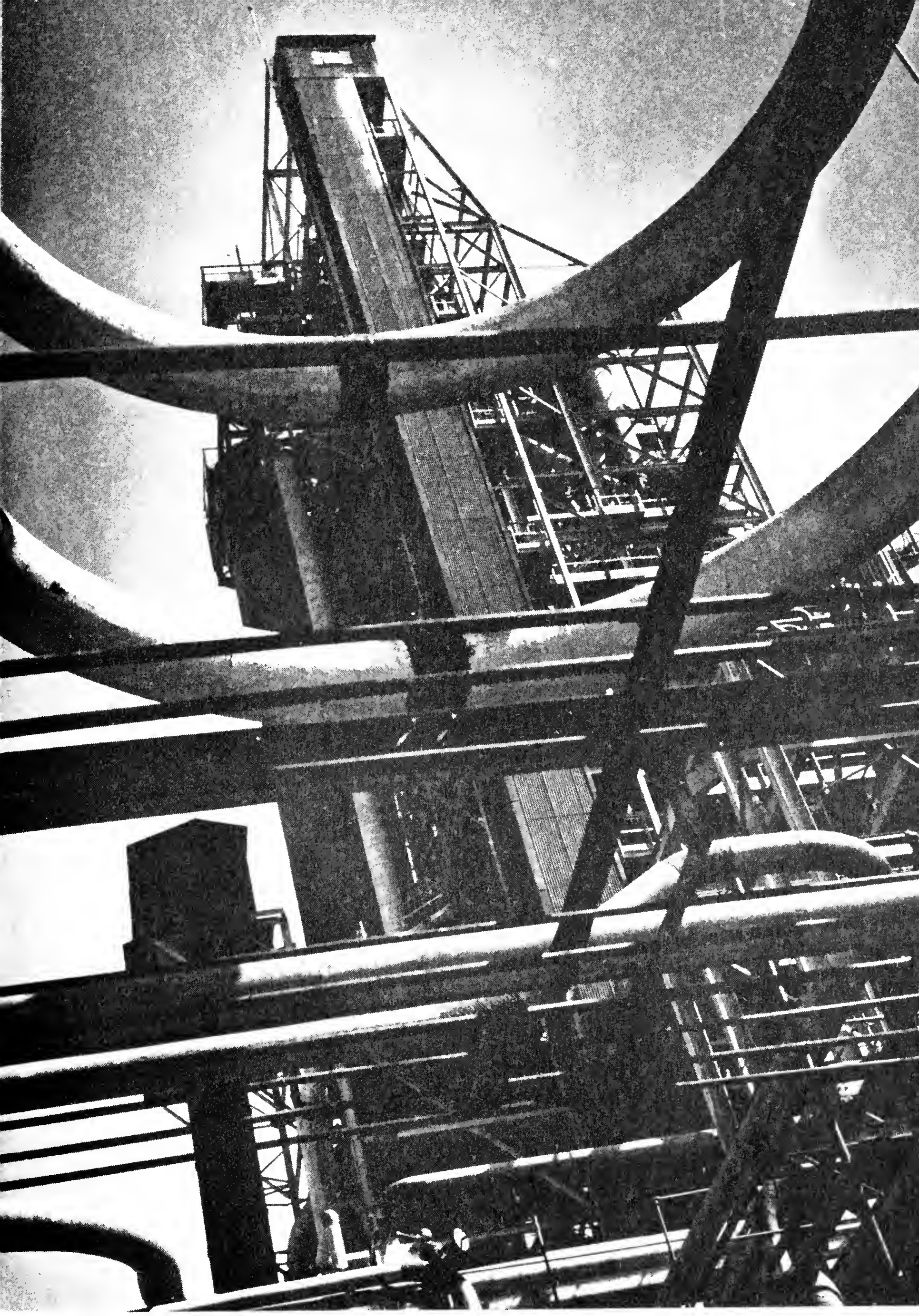
the nests for our blimps . . .



Socony-Vacuum Oi

the big cracking plants.

Signal

They built the atomic bomb plants.

U. S. Arm

Chrysler Corp

Always they were building.

Signa

Army Engineer and Contractor and Seabee, they built the roads.

Signal C

They fought wilderness . . .

Signa

and mud.

Standard Oil Co.

Their roads skirted the Arctic . . .

Sign

cut through jungles . . .

Signal

coiled about mountains . . .

Sign

bridged a thousand streams.

Sign

And our armies rolled on.

13

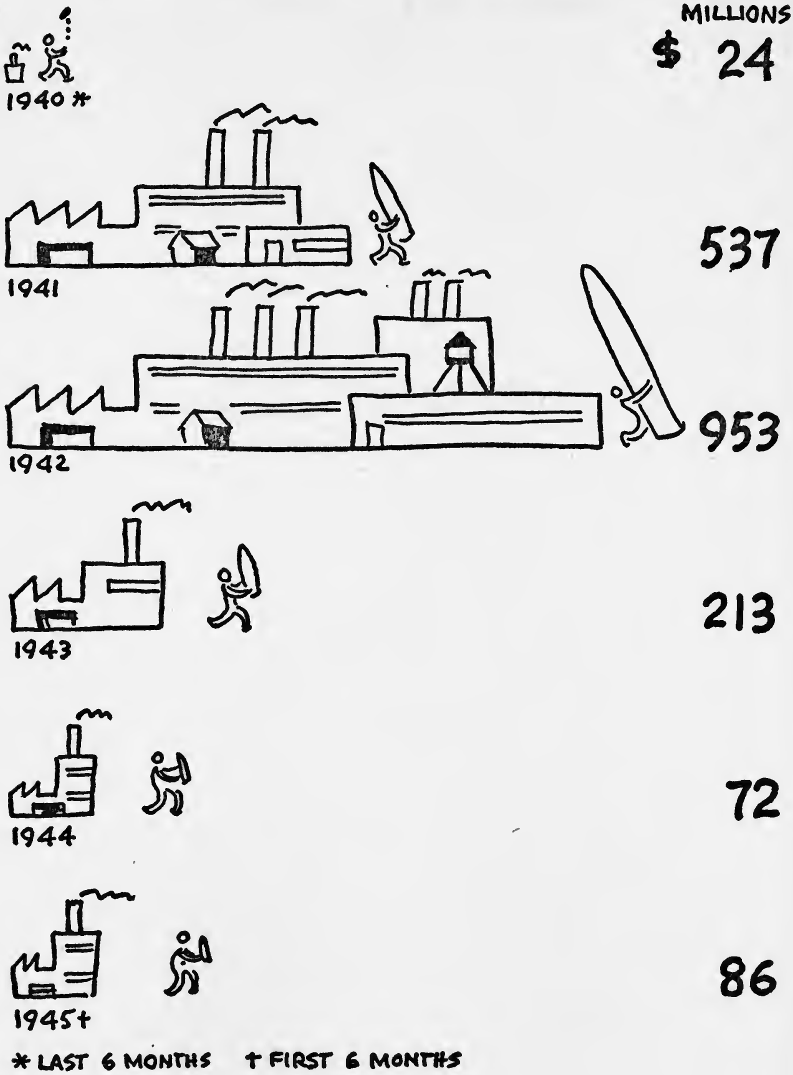
A Thousand More Jobs

MORE and more construction jobs were pushed through in a matter of days. Some were jobs like the building of supply depots with their warehouses and railroads and highways; some were small but exceedingly interesting, like the construction of replicas of Jap pillboxes and houses complete with Japanese furniture; others dealt with the construction of thousands of concrete igloos for the storage of explosives, the building of hangars for our blimps and planes, the erection of tank arsenals to turn out our lumbering, gun-snouted giants.

Contractors completed thousands of jobs, varying from the construction of a bomb shelter for the White House to the building of facilities for the Air Transport Command, which on V-J Day had a fleet of 3,700 planes, a spider-web of about 166,000 miles of routes over the globe, and was stopping at 330 foreign ports. Shortly before the end of 1945, ATC was traveling some 2 million miles every 24 hours, a distance equal to 80 times around the world at the Equator; was carrying 200,000 passengers a month, or about the population of San Diego, California, or Syracuse, New York.

Then there is that nightmare of all strangers in Washington, the Pentagon Building, its roads writhing about it like so many snakes. It established an all-time high for bigness and was built in record time—a 100-acre office building housing some 30,000 workers. Sprawling over the Virginia countryside, it rests on 42,000 piles and contains enough concrete to build 11,000

We Built To Make Explosives and Load Ammunition



average-size concrete homes. It is the biggest conglomeration of ramps and caverns and pigeonholes in the world.

Another vast contract-construction program was the building of ordnance plants. We needed these manufacturers of death desperately and we threw them up out of farm land so rapidly that at one time the good earth seemed to blossom forth with shells and bombs, torpedoes and machine-gun bullets. As the war progressed, it soon became obvious that .30-caliber machine-gun ammunition did not have sufficient hitting power and that we needed more and more of the .50-caliber. This meant a tremendous increase in plants to produce the larger size.

Some of these ordnance plants were very large, one in the Middle West extending over a 4-square-mile site and containing 225 buildings, some of which are two stories high, a city block wide, and two city blocks long. On this particular job we hauled some 10 million cubic yards of dirt, almost enough to build three pyramids the size of the Great Pyramid near Cairo. We built firing ranges, control towers, target houses, powder magazines, ballistics buildings. When the plant was in full operation, it poured out .30- and .50-caliber ammunition at the rate of 13.5 million rounds a day.

Then there were the ordnance installations in Nebraska, Oklahoma, and Indiana. The smallest of these spawning grounds of death covers 71 square miles.

And there was Canol, that controversial project for supplying oil and gas to planes flying the Northern route through Alaska and the Aleutians. Here we drilled for oil at Norman Wells in the Yukon Territory near the Arctic Circle, laid 1,600 miles of pipe line through frozen wilderness and over the unexplored Mackenzie Mountain Range, hauled a refinery up from Texas and put it together at Whitehorse, and transported our supplies and equipment over 1,200 miles of rivers, lakes, wilderness, and moun-

tains, just to get to the job at Norman Wells—all this while the temperature hovered around 60 below.

Some idea of the ruggedness of the Canol job can be obtained from a sign at the contractors' employment headquarters at Edmonton. It reads:

THIS IS NO PICNIC

"Working and living conditions on this job are as difficult as those encountered on any construction job ever done in the United States or foreign territory. Men hired for the job will be required to work under the most extreme conditions imaginable. Temperatures will range from 90 degrees above to 70 degrees below. Men will have to fight swamps, rivers, ice and cold. Mosquitoes, flies and gnats will not only be annoying but will cause bodily harm. If you are not prepared to work under these and similar conditions, DO NOT APPLY."

Far from the bitter cold of Canol, around on the other side of the globe, other contractors fought to turn North Africa and the Middle East into an arsenal. At Massawa in Eritrea they found the harbor full of ships sunk by the Italians. One of their first jobs was to lift the ships off the bottom, and to salvage two Italian dry docks. Then they built a naval base with all its facilities, a rest camp, ammunition depot, roads, airports, underground fuel-storage tanks.

All through Northern Africa they built. In Egypt, at Heliopolis, they tossed up a general-repair depot covering over two square miles and providing housing for 10,000 men, complete overhaul and repair shops, a Diesel-locomotive repair shop and school, a 1,000-bed hospital. In Kenya Colony they built oil-pipe lines and fuel-storage facilities in some of the best game country in the world, a kind of hunter's paradise with herds of elephant, giraffe, antelope, gazelle, zebra, wild buffalo, lion, and leopard. Farther north, in the Anglo-Egyptian Sudan, it was more

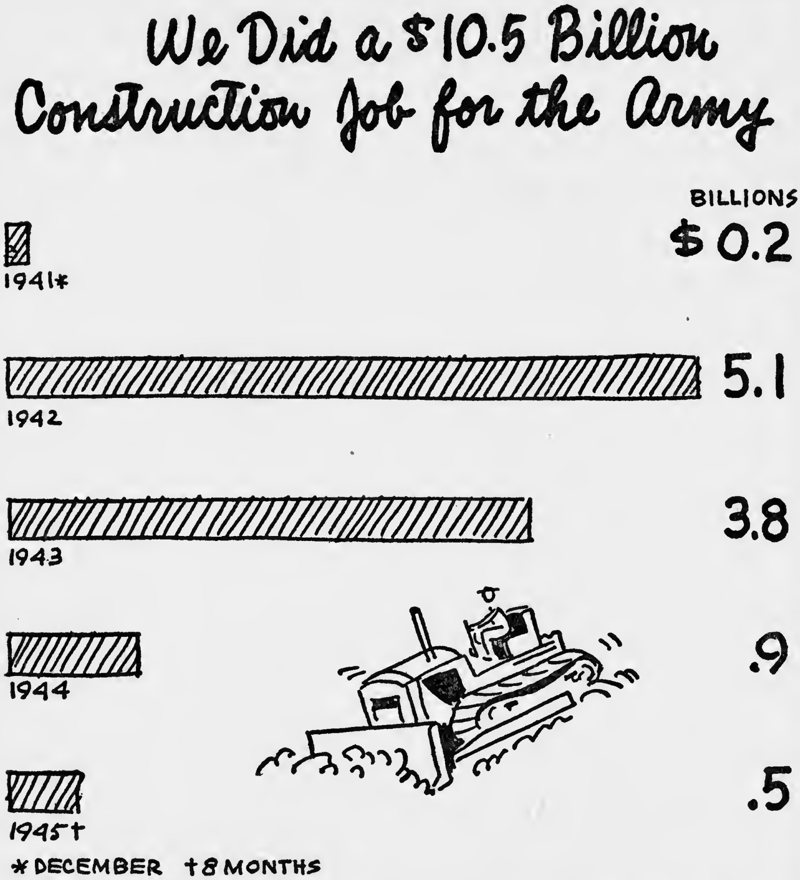
service camps and airports and fuel-storage facilities, all the way from El Geniena to Khartoum. When they first tore into the job, fuel was being hauled by camel to some of the outlying air-route stations, a distance of nearly 1,000 miles. To get in with their equipment and materials, they used camels and trucks. The trucks often stayed in "low" for half-day stretches, grinding through the loose sand. They did things like that while the temperature at Khartoum varied from 120 to 165 degrees.

In Arabia the contractors hired camels from the local sultan and hauled in their supplies to the sites, which were little more than hot desert islands or barren stretches of coast. Yet these sites were valuable because they were strung at strategic points along the air route to Calcutta and Chungking, and we needed to establish American landing fields, living quarters, water supply and fuel-storage facilities. Palestine also heard the rumble of their heavy equipment, felt the bite of their dozers and shovels. Here they built another general-repair depot with shops and barracks.

Along an arm of the Persian Gulf in Iraq they were busy building a railroad, wharves, and roads, when the High Command, because of strategic considerations, ordered the entire operation moved into Iran. So they tore up their stakes and moved, and started over again. Sometimes, when modern building materials failed to arrive at the ends of their long supply lines, they turned to using some of the world's oldest materials, building entire installations out of sun-baked bricks of mud. When equipment didn't show up and when they couldn't get trucks and graders, they used hordes of natives with baskets and donkeys. Somehow, always, they kept going.

It wasn't that the construction was particularly difficult, in fact it was relatively simple, but it was the endless series of seemingly little things that made the job tough—and some of them were not so little at that. The contractors tell about censored mail

that never seemed to arrive, coded cables that were delivered garbled and unintelligible, having been dealt with by the officials of five different governments. And then there was the climate. In the winter floods rushed down on them and turned the desert into



a vast lake, leaving it impassable for weeks. Late spring found them fighting sand and dust storms that whipped about them for days at a time. And in midsummer they sweated and struggled through heat which during August averaged 122 degrees at their headquarters in Ahwaz. But they did the job. The supplies for Russia went through.

14

Democracy Works

But the men and women who tore open the earth and built our war plants and cantonments and other facilities were not the only ones who made the war-construction job possible. There were also the men who worked with the Government on policies and procedures, who straightened out confused regulations, kept the men on the construction front constantly informed, snipped red tape when it threatened to choke progress on vital projects, and in a thousand other ways helped war construction meet its grim deadline.

Their work was not spectacular or dramatic. You don't find the sweat and the hard muscle and the courage in their story. You don't see the march of the cranes and dozers and big shovels over the horizons of the world. But their work was of vital importance. Indeed, if they had not performed efficiently, the entire war program would have been handicapped, perhaps seriously delayed.

They were the little-known men, the ones tucked away in office buildings thousands of miles from big construction jobs, the ones who fought for their country from flat-topped desks, whose battlefields were conference tables, and who sometimes worked twelve, fourteen hours a day for months at a time. They'll never get much notice, but some of them gave all their time and their health to bring out of the dream stage those huge war plants and cantonments and ships.

For years these men had been working for improved conditions in the industry they represented, for higher standards of

performance, and for greater efficiency. In fact, that was their job. As staff members of trade associations, professional societies, and unions in the construction field, they were familiar with construction and its many problems, had long maintained close contact with the industry, and knew what could and could not be done in the little time we had to build for war. They knew how to get things done, and the Government knew that they knew.

The Government knew that construction would be the first industry to turn to war work and that instead of following precedents, these men would have to establish them. It knew that many problems in this industry were radically different from those in other fields and that their work would be complicated by an almost infinite variety of projects that would have to be carried out under all kinds of conditions throughout the world. In addition, there were a multitude of federal, state and local laws to contend with which did not affect other industries.

The problems kept piling up and soon the men in the trade and professional groups found themselves practically drafted for the duration. Through them and their organizations the Government assembled data on the resources of their industry, its capacity, its established methods of operation, its organization and, in general, how the industry functioned. With this information at its finger tips and with the advice and suggestions of these men, the Government was able to draw up policies and procedures that would make sense and help cut red tape to a minimum. It could operate and make decisions based on facts rather than on bureaucratic guesswork.

Another part of their work involved the interpretation of the myriad laws, rules, regulations, orders and directives so that they could be understood by the men on the construction front. This task, of great importance in keeping the ball rolling all the way down the line, meant endless conferences with officials, the

preparation of bulletins to the membership of their organizations, and a clear understanding of the Government's needs. The work varied from showing how contractors could be mobilized for building the Alaska Highway to pointing out how a regulation drafted to conserve gas should be modified so as not to stop construction work on the most urgently needed airfields and other facilities.

The job of transmitting information on government actions affecting the payment of wages, employment of men and women, use of materials and equipment, type of production, profits, and other matters, was in itself a difficult task. And sometimes the men in the various industry organizations were literally swamped with mountains of official releases on about everything from priorities on screws to rental requirements on fifty-ton cranes. During 1943, the Associated General Contractors of America, for example, found it necessary to transmit an average of six bulletins a week, one each working day, to its local groups to keep them informed of government needs or actions.

Another one of their jobs was to help their membership on just about every kind of problem that might, and quite often did, arise on a war-construction project. This work might not have included a ruling on the time spent by Rosie, the riveter, in applying lipstick, but it included about everything else. The telegrams would pile higher and higher on their desks, the telephones would ring every few minutes, the mail became a kind of nightmare. Always there were cries for help and questions. "How can I get a million board feet of Number 2 pine in three days?" "Who's the blankety-blank holding up my priority on steel?" "The General says he's got to have that cantonment finished three months ahead of schedule. How can I get six carloads of nails?" "I got a strike on my hands, do something!" "What's happened to those power shovels the Army promised me?"

At times it must have seemed that the whole world was stuffed with wires and letters and questions. Almost every few minutes there were questions, and if someone hadn't answered them promptly and accurately, hadn't straightened out the tangles and messes that gave rise to them, well, things wouldn't have gone so well on the construction front.

The mechanics of some phases of the work of these men in the trade and professional organizations is interesting. They didn't sit around and twiddle their thumbs, waiting for war, before they started hammering at some of the problems the Government was likely to face in the event of an emergency. As early as 1934, for example, the Associated General Contractors of America, upon the request of the Army Industrial College, had secured outstanding general contractors to address classes on how the construction industry might be used during war periods.

Again, in 1938, the War Department called upon that organization to confer on terms of wartime contracts. Already, the Associated General Contractors had consulted with the Navy Department on problems of construction of the Pacific naval and air bases.

Later, in May, 1940, the month when the President sent his first defense message to Congress, the Army and Navy Munitions Board appointed a Construction Advisory Committee. This committee, which did the spade work for the war-construction program, was composed of John P. Hogan, president, American Society of Civil Engineers, chairman; Edward P. Palmer, past president, The Associated General Contractors of America; Alonzo J. Hammond, president, American Engineering Council; Stephen F. Voorhees, past president, American Institute of Architects; Malcolm Pirnie, general chairman, Construction League of the United States; Edward J. Harding, managing director, the Associated General Contractors of America, who was succeeded

on his death by Herbert E. Foreman, the new managing director of the Association.

The Board put before this committee a question of fundamental importance to the development of the war construction program. And that question was, could the industry expand fast enough from the low levels of the thirties to do the war construction job, or should plans be made for getting the necessary construction through other means? The survey conducted by the committee showed the Government that the industry could do the job, do it better and faster than it could be done through any other means. The committee also recommended policies that would enable the Government to obtain maximum productivity.

After war construction was over the hump and most of the facilities had been built, construction groups organized a Construction Advisory Committee to cooperate with the War Production Board and other government agencies in developing means of turning the excess capacity of the industry into other vital war work. This group, composed of representatives from 18 organizations, also had the job of helping to plan the return to peacetime operations.

It is obviously almost impossible to evaluate the contribution these men in the professional and trade organizations made to the building of our cantonments and airfields and war plants and ships. Perhaps the best indication of the effectiveness of their work is found in the record of war construction. Writing of the Army's supply program in July, 1943, General Brehon B. Somervell, Commanding, Army Service Forces, said in part:

"The Arsenal of Democracy is in place and producing. This was the first test of our ability to work prodigiously enough to fight a global war, to plan on a big enough scale to envision victory, to wrestle with difficulties big enough to temper our steel. The test has succeeded.

"Enough facilities for housing and training five million troops at one time are in place. Three billion dollars' worth of munitions and chemical warfare and aircraft assembly plants are completed and functioning. Approximately 95 percent of an $11-billion emergency construction program is already in use. The total value of more than 1,000 army posts and sub-posts which will be maintained during the fiscal year 1944 is estimated at $11.5 billion, a sum equivalent to 90 percent of the total receipts of the United States Treasury in 1942. This is the job the construction industry in the United States did for the Army. Until this was done we could not begin to fight.

"The people of the United States, generally unaware of the total size of the job which has been done, may be thankful that the vast gearing of the army supply schedule was never held up for buildings not completed on schedule. To those who know that the first billion was really the easiest, the job which the construction industry of America has done in overcoming shortages of labor and material—and above all, of time—is a remarkable tribute to American organizing skill."

15

Contract for Speed

EVERY day counted. The Government could not proceed in its leisurely peacetime fashion and expect to get construction underway and completed in time. It had to cut red tape, design special contracts that would help insure speed, and still adequately protect the public interest.

Ordinarily, when time is not the essential factor, the Government uses the lump-sum contract. This method, long used on Federal projects, is based on competitive bidding. It requires considerable preliminary work, and is a safe and satisfactory method in normal times.

But these were not normal times. We had to have war plants and cantonments and airfields and other facilities at the earliest possible moment. A faster, more flexible contract was needed for rush jobs. After careful study of various forms of construction contracts, Government agencies adopted what is known as the cost-plus-fixed-fee contract. Under this contract the fee is fixed and is not affected by variations in cost, but only by changes in the scope of the work. Its big advantage is speed. Under it preliminary work can be cut to a minimum and construction projects can be started in a matter of days.

In discussing lump-sum and cost-plus contracts, William M. Smith, Special Assistant to the Chief of the Bureau of Yards and Docks, Navy Department, and an authority on construction contracts, has this to say: "In times of emergency involving the national defense, when it has been determined administratively

. . . that certain projects are of such importance that their accomplishment with the utmost speed and certainty is imperative, the cost-plus form of contract is practically essential.

"In some cases, as where the location is isolated and where the engineering data available are meager, it is the only contract method that will bring the desired results. Where the early completion of a project is important, any time that can be saved in starting construction work in the field will contribute to that end. Contract work in the field cannot be started until a contract has been made and a contract based upon competitive bidding cannot be made until prospective bidders have been furnished plans and specifications sufficiently descriptive of the work to enable them to estimate what it will cost to do it. To be sufficiently descriptive the plans and specifications must generally be comprehensive and indicate all details that may affect costs. This means numerous plans and complete specifications which require much time for preparation.

"On the other hand, a cost-plus contract can be made without the prospective contractor having more than a general outline of the work to be done, because he does not have to figure accurately the cost. Changes in requirements can be met without the delay and paper work incident to supplemental agreements or change orders required under the competitive-bidding form of contract. The requisite working plans and specifications are prepared after the contract is made and as the work progresses and as they are required. Much preliminary work can often be gotten under way, or even completed, from sketch plans which can be prepared quickly. Thus, most of the time ordinarily required for the preparation of bidding plans and specifications and their distribution to prospective bidders, the preparation of bids, the opening of bids and the awarding of the contract can be saved.

"It is estimated that it would have taken at least 12 months to have prepared competitive plans and specifications for the Pacific islands naval air bases—funds for those projects were appropriated by the Act approved May 25, 1939, and the cost-plus contract was executed August 5, 1939. Estimating three months for the preparation and opening of bids, analysis of bids received, award and execution of contract, it will be seen that the work in the field under the cost-plus contract . . . was practically a year ahead of what would have been the status on a competitive-bidding basis.

"Furthermore, had the usual competitive-bidding procedure been followed in this particular case, it is certain that bidders would have included in their proposals a large contingent item to protect themselves against the usual hazards of long sea voyages for personnel, plant, and materials; of housing and caring for employees, including maintenance of their health and morale on isolated islands having no existing facilities; uncertainties of labor supply for outlying islands; uncertainties of weather conditions in the mid-Pacific; and other unforeseeable contingencies. This would have resulted in high bids and might have forced an award to an imprudent, and hence an unreliable, bidder who had gambled on a contingent item, and who, if a serious loss appeared, would stop work and throw the job in the lap of his sureties. In that event the Government would have increased indirect costs and a lawsuit on its hands and face a delay of uncertain duration in the accomplishments of its projects. On the other hand, if any or all of the contingencies did not materialize, the Government would pay for something of no benefit to it and the contractor's profit would become unduly large."

In addition, and most important of all, as events proved after Mr. Smith's statement was written, we would have been even

worse prepared in the Pacific than we were. Our Pacific-base construction would have been slowed up and results might well have been disastrous.

Without the improvement of defenses at Midway, for example, we might have lost that decisive battle. The contract for building defenses on Midway was awarded in August, 1939. It was for $3,750,000 and the work was to be completed in August, 1942. As the work progressed and the clouds of war became more menacing, the original contract was greatly increased. By the time of the Battle of Midway, which started June 3, 1942, the value of work completed amounted to $19,795,000, about five and one-half times the sum called for in the original program. In other words, more than five and a half times as much work was completed as was originally called for and in less time.

If the base had not been ready, if our bombers and fighters had not been able to take off, instead of the Japanese Navy suffering its first decisive defeat in 350 years, it might have won the engagement. A Japanese victory would have cut off our lines of communications, and enabled the enemy to continue their advance on Australia and the islands of the South Pacific.

16

Construction Rides a Rocket

We hitched construction to a rocket and we paid for rocket speed, not 20 miles an hour, but 1,000 miles an hour. We built faster than we believed possible. If the mercury fell to 20 below for weeks at a time, we built just the same. If snow was three feet deep, we built. If the site became a sea of mud, we built. Regardless of anything, we built. Speed meant saving human lives, and speed costs money.

It costs money for a good many reasons. Let's take an example. Suppose you have the contract for building a cantonment in 150 days. In normal times, maybe you'd build it in two years. You'd take your time and pick the best foremen and the best skilled labor, arrange to get the right materials at the right prices at the right time. You'd make sure you had the right kind of equipment for the right parts of the job, and not something that would slow up operations or at best be a substitute or makeshift. And you'd check a lot of other things.

Now suppose you have to do a two-year job in 150 days. The Army is depending on you. You have got to do it. If you don't, you may be responsible for some general not getting a division on time or a bunch of American boys not getting replacements.

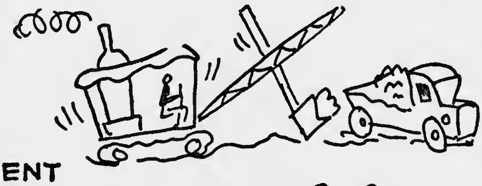
The day you get your contract you start hitting into the job with everything you have. Your own bulldozers and carryalls and all the others you can rent are rushed to the site. Some of them are old and expensive to operate, but they can still push dirt around; besides they are the best available. There isn't time to

Life Depended on Speed So We Built—

NIGHT AND DAY

IN ICE AND SNOW

IN RAIN AND MUD



WITH ANY EQUIPMENT

WITH ALL KINDS OF LABOR

And We Built Faster Than Ever Before . . .

pick and choose foremen and labor. You take what you can get and train and develop them. Some may have been school teachers, clerks, school boys, almost anything.

Then the hunt for materials begins. Common brick is scarce but there's plenty of face brick. You take that; it's expensive, but you've got to have brick. Maybe you can't get Number 2 common pine for sheathing, so you take a slightly better grade. Then a shortage develops in steel; you've got to use more wood. As you go ahead with the job, you substitute one material for another, sometimes using a more expensive material and sometimes having to lug in more power saws or concrete mixers or trucks because of changes.

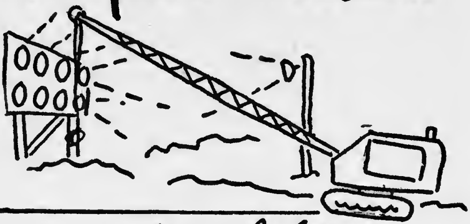
You can't afford to be particular about when the material is to be shipped. If 30 carloads of plumbing arrive just as you're breaking ground, you throw up several shelters and store it, although ordinarily you wouldn't think of having it on one of your jobs before the right time. If extra carloads of lumber show up a month before you're ready for it, you unload it wherever you can find the space. If the lumber had arrived at the right time you would have trucked it directly to the site, maybe taking some of it into your cutting yards direct from the cars. Its early arrival means it's got to be handled two or three times, and that's more money.

Then maybe it rains for two weeks. The roads into the site turn into mud. Trucks sink into it. At first you manage to rent some extra tractors to pull them through. But the going becomes tougher and finally you make sleds and drag them through the mud. It slows up the job. So you put on more tractors, more sleds.

Finally, in spite of a long series of promises, one of those hard-to-get materials doesn't show up. Half your labor force is idle. You switch them to other odd jobs, but still the stuff doesn't show

We Paid for Speed Because—

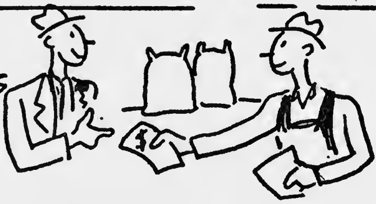
NIGHT WORK
COSTS MORE



WINTER WORK
COSTS MORE

INEXPERIENCED LABOR
COSTS MORE

SUBSTITUTE MATERIALS
SOMETIMES
COST MORE



OPERATION OF OLD EQUIPMENT
COSTS MORE

up. Some of the men will stay, waiting until they can go back to work. Others will say to hell with it, and pull out. Then when the material turns up, suddenly, unexpectedly, you go out and search the countryside for more labor. You become desperate, you take whatever you can get, and work overtime. Some of the labor is third rate, and that means more money.

All this time you're pushing around, improvising, using all the shortcuts and tricks you're able to cook up. Finally you complete the job.

Maybe this sounds like a kind of horrible example, but it's not. A great many war construction jobs had to meet the same hard obstacles. Time and time again mud sent costs soaring beyond estimates.

There was that job, for instance, in the South, where the contractor had to build an access road out of wood, floating planks on the mud. Then he was forced to pave the entire area about his cutting and lumber yards with more wood, using a total of some 7 million board feet, enough to build 700 average frame homes, just to get material to his job. The mud was so deep and soft that the ditches for his sewers collapsed before he could lay pipe, so he ran his trench digger slowly, had a crew follow it to slant the sides of the ditch, and another crew to place flat boards and bracing in it to hold back the sides during the time pipe was being laid.

Another time, in the Middle West, a contractor had brought some of his men onto a new job, made all arrangements, figured out his schedule and organization and transportation, when suddenly the site was changed because of an inadequate water supply.

Other times, the contractors had to heat frozen ground with steam and strip off the resulting mire before they could pour concrete slabs. And there were times when they couldn't wait for

railroad spurs and had to build long stretches of road over all kinds of terrain just to get to where they could start working.

There were innumerable examples of this kind. In fact, the war construction job without at least a few of them was rare. But in spite of these and other obstacles, they got the job done.

17

Moving Day

Even before they finished the war plants and the cantonments they turned their dozers and power shovels into the battle of delivering matériel.

For the invasion of Europe, General Eisenhower needed, and got, 48 million tons of supplies. Thirteen million tons were in the form of local aid from Britain and France, practically all the rest, or 35 million tons, came from this country.

It is hard to visualize that much matériel, but if you wanted to haul 35 million tons on a freight train, you'd need a million cars and the train would be 8,600 miles long. Or, if you decided that was too long, you'd need about 30,700 average-length trains to do the job.

Getting all that to the European theater was not easy. First, you had to build shipyards to make the ships, install more loading facilities at our ports, build more warehouses and storage depots, more airfields and hangars. Over in Europe you had to deliver millions of tons in spite of destroyed ports, wrecked railroads, blasted highways, smashed bridges, ruined airfields, and bombed-out canals.

Of course, it was more than a construction job; it demanded all the transportation skill and industrial know-how the country possessed. But it was based on construction, just as the production of weapons was based on construction. You can't get millions of tons of matériel across the ocean and through muddy fields to the front without construction.

We had to have the facilities; and we got them. We restored the ports, the railroads, the highways, the bridges, and the canals. We built airfields, warehouses, storage depots, pipe lines and all the rest. And we pushed millions of tons around France so rapidly that our armies were able to advance faster than any other army in history.

The extent of this part of the construction job is roughly indicated by the volume and variety of matériel moved. Up to V-E Day we landed 80,000 tanks, tank destroyers, armored cars and half-tracks. We put on the coast of France 700,000 vehicles, 50,000 pieces of artillery, more than 3 million small arms and automatic weapons, and millions of rounds of ammunition. There were millions of tons of food, thousands of tons of clothing. All in all there were 700,000 separate articles, everything from a shoestring to a tank retriever. There were surgical instruments and locomotives, fountain pens and bulldozers, spools of thread and 45-ton trailers.

During the height of our campaigns in Germany and France we used some 7 million rounds of ammunition and a million gallons of gasoline every 24 hours. Delivering petroleum products alone was a herculean task, involving the handling of more than 7 million tons.

To get this matériel off the beaches, sometimes through mud thigh-deep, over bombed-out railroads and wrecked highways, required construction ability of the highest order. In doing the job we used the same big equipment we had used at home: the bulldozers, the carryalls and the power shovels.

We dragged across France to the inner fortress our giant 60-ton cranes and concrete mixers capable of turning out 34 cubic feet of concrete per minute. Never before had such an array of equipment marched into battle, and never before had armies raced to their destination so swiftly.

This, then, was now the construction job: to build so that armies and matériel could move rapidly and strike hard. They did it in Europe and the Pacific, and they did it in the face of machine-gun, mortar, and artillery fire. They did it in heavily mined areas, in mud that reached to their knees. In spite of hell and high water, they did it.

18

Bullets and Bulldozers

In reality most men in the Army Engineers are not engineers at all. They are primarily construction workers, men who in civilian life would be building skyscrapers, dams, railroads, highways, factories and so forth. They are bulldozer men and carpenters, crane men and welders, riggers and steel workers. Just about every construction trade is represented. Their officers are engineers and architects, contractors and foremen. And they build everything a modern army needs before it can so much as fire a single bullet.

You didn't hear much about the Army Engineers during the war because somehow they didn't seem very spectacular. Not nearly as sensational as those thousand-plane raids over Europe, or General Patton's drive across France, or D-Day on the Normandy Coast. Yet without the Army Engineers, big air offensives would have been impossible, General Patton would have crawled across France at a snail's pace, and D-Day might still be in the dream stage.

The German General Staff knew the Army Engineers well. They knew that huge bomber bases were built in England before they even thought it possible to build a few fields. They knew that the wrecked railroads of France suddenly came to life and carried supplies weeks in advance of their estimate. They knew that Cherbourg and Le Havre started functioning as big ports in spite of some of the most thorough wrecking operations in the war. And they knew that airfields were carved out on the heels of

our advancing doughs in a matter of hours, that bridges were thrown across rivers so fast it almost made them dizzy, that pipe lines poured gas to Patton's fast-rolling tanks. Yes, they knew the Engineers well.

And the dogfaces knew them well. They'd seen them dozing out roads from the beaches while machine-gun bullets bounced off their bulldozers, seen them smash enemy pillboxes and take the bite out of antitank traps, dig up thousands of mines, blast enemy positions, build airfields, highways, bridges, then grab tommy guns and defend what they had built. And they'd seen them go calmly about their construction jobs while machine-gun bullets zinged overhead and shells blasted out great geysers of sand.

At bloody Omaha, for instance, they watched two dozer men take turns in running their bulldozer back and forth across the beach. Between crackling bursts of machine-gun fire, they heard the sputtering of the machine as it went about its work. As the battle raged, the dozer lowered its steel snout and rooted out capsized vehicles blocking exit roads, pushed away roadblocks, smothered antitank traps, clanking over them triumphantly.

There was no armored cab and the two men on the dozer were completely exposed. They sat there and took it. When the Army awarded them the Distinguished Service Cross, the citation read simply: "Their courageous actions permitted vehicles and armor to move out to the support of the infantry."

Sometimes the Engineers had to fight as well as build. There was, for instance, the fighting at Fortress Montabarray, before Brest. This fortress, which was defended by fanatical Nazi paratroops, stood squarely in the way of our infantry. Several times we tried to crack it. But every time we got a toehold, the Krauts came back at us and beat us off.

The job was tossed to the Engineers, who under cover of flame-

throwing tanks approached the outer wall. They planted two tons of explosives and knocked a hole in it big enough to drive a couple of trucks through. Then, using scaling ladders, they climbed over the inner wall, hauling the ladders up with them. They fought their way down into the courtyard. After bitter hand-to-hand fighting, the Jerries surrendered.

But building was their really big job and there are many stories about their routine operations, the little things that made up a day's work. For example, the one about Robert Parker whose General said he did a very good job. If you'd been there you would have seen him manipulating the levers on his dozer, yanking the machine around, letting her big blade drop, then charging behind a rippling stream of dirt at a sea of little flames skipping toward an ammunition dump. He smothered some of them with dirt, backed up, wheeled, and the machine rumbled forward, spreading more dirt over the flames which were racing toward the shells. Again and again he did it, finally burying the fire. It's just a small thing, say the Engineers; and it's a safe bet that not one in ten thousand of them ever heard of Robert Parker, even if he did save millions of dollars' worth of ammunition, even if it did take some nerve to run a slow-moving dozer around a dump that might explode any second.

War is made up of a multitude of little things like that. Things like the one Private Phillip H. Potter did on November 25, 1944. He is a light-truck driver and was a member of a detail whose mission was to bridge a crater which was blocking a scheduled attack. Several times they tried to take the needed equipment to the site and each time they failed. Then Private Potter volunteered to drive a 25-ton bridging truck down the road. He got in his big truck and started to roll down the road to the crater. The Jerries let him have it. They let loose with artillery and mortar and small-arms fire. Shell fragments smashed through his truck,

bullets riddled his cab, pierced his clothing in several places. He kept going. He got to the crater. After helping to place the first span of the bridge, he returned, got another truck and rolled back again over the same dangerous route. The Jerries were waiting for him, but he got through.

Then there was the Engineer who parachuted down in the Papuan Jungle with surveying instruments, a tommy gun, rations, and antisnake venom. When he landed deep in a swamp he pulled himself out and calmly went to work surveying the jungle. He marked the land he had laid out and trudged through jungle, wading streams, cutting his way through matted underbrush, until he arrived back at headquarters.

Then the Engineers listened to him and sent out more men to parachute down on the spot he had marked. They were followed by baby bulldozers, sheep-foot rollers, rotary tillers, and other equipment. All were dropped by parachute to the waiting men in the jungle. Later, rolls and rolls of steel mat came sailing down from the sky, and before the Japs even knew anything about it, we had a fighter strip right under their noses. Almost daily, our planes rose to shoot down their Zeros.

There are thousands of stories like that. Tales about how they sliced out airfields in the Aleutians, knocked roads through tundra, built camps, and as a side line shot Japs. Where the tundra was too deep to rip off with their cats, as on Adak, they devised floating roads. They threw bridges across the Rhine in jig time, snaked pipe lines behind our advancing armies, cut roads around mountains, cleared mountain passes and beaches of mines, and laid railroad track.

Construction huskies, Engineer troops, constituted about eight per cent of the total strength of the Army. There were combat Engineer Battalions with each Infantry Division and there were general service regiments, but in addition we had various spe-

cialized units—amphibian engineers, port-construction and repair groups, water-supply companies, petroleum-distribution companies, power-plant-repair companies, topographic battalions, forestry battalions, refinery-tank-construction and pipe-fitting companies. The entire list includes 30 different types of Engineer units.

They had two major jobs. One was the job of destruction—to wreck German and Jap installations, that is, to clear mine fields, tear out the teeth of antitank traps, destroy underwater obstacles, blow holes in fortress walls, and that kind of thing. The other job was construction, and it soon became a matter of who could move the most dirt first. It was as General MacArthur told Major General Reybold, Chief of the Army Engineers: "This is an air and amphibian war and because of the nature of air and amphibian operations, it is distinctly an Engineer's war."

Such a war of construction was a "natural" for the Engineers. For years they had supervised construction on flood-control projects, and river and harbor improvements. They had the vast resources of the construction industry to draw from, the heavy equipment, the experienced personnel, the sources of technical information, the methods. They had for the asking all the accumulated experience of contractors and engineers who had built our big hydroelectric dams, bridges, railroads, industrial plants, highways, and other facilities.

We are a building nation and used to taking huge construction projects as a matter of course. Our bulldozers, power shovels, pile drivers, cranes, and carryalls are to us rather commonplace. But to the Germans and the Japs they appeared to be steel miracles. When the Japs saw that our biggest bulldozers could move as much dirt in a single day as they could move by hand labor with a thousand men, it was enough to set them back on their heels. With equipment of this kind in the hands of men who

knew their business and with methods used on thousands of peacetime construction jobs, we had a decided edge on the enemy.

It is an old truism that the size of the base determines the number of troops and the quantity of equipment that can pour through it to attack the enemy. If it is impossible to prepare a base of a desired size within the time limit, the attack is either not launched or, if launched, is likely to fail. Another equally basic fact is that modern mechanized armies with their insatiable demands for supplies must have transportation arteries—facilities in the form of railroads, highways, airfields, and ports. Indeed, the speed of an advancing army is determined largely by the speed with which it can be supplied.

In this sense, the Army Engineers were partly responsible for the lightning-like stabs we made against the enemy, and for keeping our forces rolling in all kinds of weather over some of the most difficult terrain in the world.

Take for instance, the Ledo Road. You can't even look at this life line, hacked through the jungles of Burma, plunging down steep mountains, shooting straight as an arrow across swampy river valleys, twisting around the faces of sheer cliffs, without marveling at the determination and courage of the men who built it. But we are ahead of our story.

19

Jungle Road

When the Japs swarmed into Rangoon on March 8, 1942, they choked off the Burma Road, last overland supply route to a prostrate China. They surged northward, conquering all of Burma.

We carved out airfields in India, we flew the "Hump," we built pipe lines, but we had to have a road to get at the Japs in Burma and to roll supplies into China. Many said the project was impossible. The British had tried and failed. We had tried and made pathetically little progress.

Then we started to dig in, slicing out the Ledo Road from the little jungle bazaar of Ledo in Northern Assam, India, to Wanting on the Burma Road. We built it through country never before seen by white men, inhabited by head hunters, swarming with malarial mosquitoes and giant blood-sucking leeches. We pushed it through swamps, over rivers, around mountains. We fought the Japs, the jungle, the mud, the monsoon, and the heat. But we built the road, 478 miles of it.

Over this road convoys would start rolling at Ledo, south of which a railroad ran on down to Calcutta. They would go through Mytkyina, scene of one of the bloodiest sieges in this part of the world, through Bhamo, and then to Wanting on the China-Burma border. From there the convoys would roll over the old Burma Road, now rebuilt to accommodate them.

One part of the Ledo Road follows the same jungle trail refugees used in their escape from the Japs. There were 30,000

of them—men, women and children—dragging their way through mountain passes, wading flooded streams, wearily stumbling through the dark and silent jungle. The terrible monsoon of 1942 beat down on them and the mud swallowed their feet. Some died in their tracks from sheer exhaustion, others succumbed to malaria, some drowned in the roaring streams, and some starved to death. Fathers and mothers carried their children until they could go no farther, and at some places on the trails you will find the rotting bones of small families very close together. Ten thousand of them died; twenty thousand survived.

Now, over parts of this same trail the Army Engineers were driving a road that would enable Chinese and American troops to get at the Japs in Burma. The road, started at Ledo in December, 1942, had reached the 47.3-mile mark when work bogged down with the onslaught of the monsoon in March. We could not beat the mud. It stopped our dozers cold. It pulled trucks down to their axles. It grabbed your shoes and made walking a man-killing job. The slides completely covered our equipment—the washouts threw dozers and trucks down mountain sides.

The supply problem became serious. They lugged supplies up to the point by porter and by burro. But the slides and washouts were too much. Burros were lost over the steep cliffs. Porters were mired in the mud. So they hauled in supplies by air, dropping them by parachute.

All during the monsoon they fought rain. Lightning ripped through the sky, crashing between mountain peaks, and tons of water poured down. It turned the road into a knee-deep sea of mud. It swirled and roared through river gorges, smashing away bridges as though they were made of matchsticks, tearing great chunks of earth and huge trees from the banks. It flooded out over the low places, drowned whole sections of road.

For months they worked, ate and slept in sodden clothes. Water

ran down their backs and their clothes clung to their bodies. Water swished around in their shoes. Water seeped under their cots, ran under their tents, rattled down on the roofs of barracks. Then it would stop and the jungle would steam—100 degrees, 110 degrees, 120 degrees. Their skins ran with sweat. Their tents and clothing became moldy and started to rot. And in the heat they'd hear the water dripping from giant trees and from high grass. Then suddenly, the clouds would burst open again.

And with the heat and the rain, there were the insects. The malaria mosquito, the typhus-carrying mite and leech, and pests like ticks, hornets, scorpions, sand flies, spiders, ants, and hundreds more. There were nearly 300 different kinds of jungle snakes, three of which, cobras, kraits and vipers, are dangerously poisonous. Then there were the seldom-seen jungle animals, no great problem, but still not comforting to think of—the tigers, leopards, bears, rhinoceroses, and others.

But the greatest enemy of all was the monsoon. In some places along the road 175 inches of rain fell, almost four times as much as the average annual rainfall of the eastern United States. One hundred and seventy-five inches of rain, more than 14 feet! It was impossible to build much road. But they worked, pulling loaded trucks through mud up to their axles, fighting washouts, holding grimly on to what they had built, and preparing for the big push in the fall.

It was in the fall that General Stilwell paid his first visit to Colonel Lewis A. Pick who shortly before (October 3, 1943) had assumed command of the road job. Stilwell trudged through the mud up to the roadhead where Pick had his headquarters. He asked Pick if he could build him a jeep trail through to Shingbwiyang. It meant 60 miles of trail through tough terrain, a stretch around sheer mountains, through jungle that shot up in your face like a stone wall, over jungle streams and rivers.

Pick turned to Stilwell, "When do you have to have it?"

"By the first of the year."

Pick hesitated, looking at Stilwell, old and tough. Pick straightened up. "I can't build you a jeep trail." He paused. "But I'll build you a road for truck traffic."

Stilwell grinned, his tired eyes swept over Pick. He shook hands, turned, and left.

The road battle was on again. The eternal fight against time and mud and jungle. It had always been that way, even from the time of the first meandering foot trails, when primitive man had hunted, fought neighboring tribes, traded with people on the other side of the mountain. Man against jungle, man against monsoon, man against an enemy—the same old story.

The jungle closed in about them like the night. It was dark and ageless and silent. Huge trees shot straight up to the sky. You could hear the dozers sputtering and coughing far in the distance; occasionally trees, centuries old, fell crashing through the jungle; stumps were uprooted, tearing out with them chunks of matted undergrowth.

They tore at the jungle for 57 days and they built 54 miles of road. Then, on the morning of December 27, 1943, the great day arrived. They plunged down the mountains into Burma's vast Hukawng Valley, breaking the tape at Shingbwiyang. General Stilwell had his road four days ahead of schedule. Behind the lead bulldozer rolled 55 trucks loaded with Chinese combat troops and equipment, first Allied soldiers to enter northern Burma on wheels.

Now they had reached the 102.7-mile mark. It was 375 miles to Wanting on the Burma Road, 166 miles of which had to be carved out of solid, virgin jungle. Before reaching Wanting, they would have to fight through another monsoon, drive across swampy valleys, throw bridges across rivers, and cut their way

around mountains. In doing the job they followed trails soaked with the blood of Chinese and American soldiers, and used armor-plated bulldozers when close to Jap lines.

In the mountain section, where the road is 102 miles long and has a minimum shoulder to shoulder width of 33 feet, they dug and hauled 100,000 cubic yards of dirt per mile. In the valley, where the minimum width is 49 feet, they moved 25,000 cubic yards of earth for every mile of road.

All in all, in the first 270 miles of road they pushed around some 13.5 million cubic yards of dirt, enough to build a dirt wall three feet thick and ten feet high from San Francisco to New York. And they hauled about 1.3 million cubic yards of gravel, or about the amount of gravel a string of railroad cars 470 miles long can haul. Some of the gravel had to be lifted from river beds and trucked 25 and 30 miles to where it was needed.

They threw bridges across ten major rivers and 155 secondary streams, making a bridge crossing for every three miles of road. The total length of all the bridges, not counting minor-stream crossings, was five miles. At the Irrawaddy River, below Myitkyina, they built the longest permanent floating bridge in the world. Here, the river is 65 feet deep and fluctuates 45 feet between its high and low stages.

At times the road ate up lumber as fast as they could cut and saw it. There was, for instance, the time monsoon rains flooded out a two-mile section and they had to build a causeway requiring over 2,400 piles and a million board feet of lumber. They cut, sawed, delivered, and put it in place in 30 days. The road devoured a total of more than 822,000 cubic feet of lumber. This is equivalent to almost 10 million board feet, enough to build a thousand average-size frame homes.

All the way into Wanting on the Burma Road they kept breaking records and piling up bigger and bigger figures on road con-

struction. But the biggest figure of all, the all-important figure—if you'll excuse a pun—was the man who ran the dozer, or who swung an ax, or who operated a crane. The man who sweated out the heat, fought the mud, dug his way through mountains. It was this man—dirty and sweaty and tired—who, with Engineer officers, whipped virgin jungle and monsoon. They did it at the end of a supply line 14,000 miles long and in the face of Jap resistance. There was no glory to it—just a feeling of being forgotten, of tiredness, of dull monotony day in and day out, month after month. That it was done at all is one of the miracles of the war. That it was done so well and quickly is a tribute to American construction know-how.

20

We Slash the Underbelly

ON THE other side of the world, Army Engineers poked a prodding finger into what had been called the soft underbelly. But Sicily and Italy were not soft. They were tough and hard—a belly plated with steel, ridged with mountains, caked with mud, bristling with guns, studded with mines.

Combat Engineers soon found that out when they made their slash at Salerno. They found it out on the bloody beaches while they cleared roads through mine fields, smothered antitank traps, dozed wreckage out of the sand, and fought shoulder to shoulder with the doughs. At Anzio and Gela and other beaches it was about the same, only with slight and not precisely pleasant variations. They dozed ramps, dug mines, built roads, while shells whined down, ripping into equipment, and sand, and flesh. At Gela they did the nerve-wracking job of clearing mine fields while the Jerries dive-bombed them, then swooped low and spat lead at them.

And when they got a toe hold and were well on their way up the road to the Alps, the job didn't get any easier. It was uphill all the way, slipping in the mud, sticking in the mud, eating in the mud. You seemed to live mud; when you were tired, as you were all the time, you slept in the mud.

And then there were the mines. They were everywhere—under culverts, on little footpaths through wheat fields and woods, fastened to trees and road blocks. They were cleverly concealed under black discs in the road, planted in back yards, buried in

ditches, hidden in houses. The whole world and all of the good earth seemed to be growing mines.

They were good mines. There was, for instance, the Teller mine, 11 pounds of explosive guaranteed to toss an American jeep around like an exploding firecracker. There was the cutely named Bouncing Betty, a seemingly harmless tin can about six inches high, much like the kind you find on grocery-store shelves filled with mincemeat and other good things. But when tripped, the tin can bounces up to the height of your waist, explodes, and shoots 300 steel balls some 200 yards.

To make things even more restful and pleasant, the Krauts buried 500-pound bombs, fused to explode at certain times or rigged to go off when tripped. More than a hundred of these 500-pounders were found buried in the airfield at Ponti di Olivia, and it was, of course, the engineers' job to dig them up and gently remove their murderous teeth.

In arriving at their estimates of the speed of our advance, the Germans would figure how long it would take their own great army to clear roads, build bridges, and get men and equipment to where they could be used. Then they would add a few more days or weeks for the Americans to do the same job, grin smugly and retire completely confident that a Nazi couldn't be wrong.

They were amazed when calculation after calculation, so painstakingly worked out, exploded in their faces. Instead of taking two weeks to rebuild a road blown off the face of cliffs, we'd blast out a ledge with beehives (directional mines). Our bulldozers would snort over the ledge, clearing it and biting in deeper, and then over would roll supplies, jeeps and troops, all in a few hours. Later, after the dozers had cut the ledge still deeper into the cliff, our heavy artillery, tanks, and other heavy stuff would be rumbling across. Time after time this happened. The Jerries would blow up a bridge, plant twenty or thirty thousand mines,

and pull out for the next mountain ridge, confident they had stopped us for weeks. A few days later we'd find half-eaten breakfasts on the next ridge.

When the Engineers stood on the banks of the Volturno and saw its swift, swirling currents, its high banks held by the Krauts, the bridging job looked impossible. It was like building a bridge across a fiercely running stream straight into the mouths of a hundred cannon. But they lugged up their smoke generators and under a thick cloud built their bridge, fighting treacherous currents and Germans at the same time.

On the main road to Rome, the Via Appia, their first pontoon bridges over the Volturno were tossed aside by the rushing water and had to be replaced almost as soon as they were finished. They made soundings under machine-gun fire and threw a heavy bridge across the river, about 10 feet deep and 360 feet wide at this point. In less than three weeks our heaviest trucks, tanks, and other equipment were dashing across. And when the spring rains whipped the river into a torrent of muddy foam, the bridge held, even though every other bridge across the river was swept away.

Bridges and roads, rivers and mud—and there was always another construction job waiting. There was, for example, the wrecked harbor at Naples, and later the ports of Cherbourg, Antwerp, Le Havre, Marseilles. We had to have ports. Without them, the Germans could push us into the sea. With them, we could launch and sustain powerful, fast-moving offensives.

21

Water Graveyards

PLUMP and squat, like a stout old lady, the Liberty ship cautiously felt her way toward a blasted pier. Off her bow the stack of a tug jutted out of the water, on her portside a freighter lay mangled, her bottom turned up. In front of her, all the way around the harbor was a mass of twisted steel, chunks of concrete, and gutted buildings. She stopped as though afraid to continue, gasping out little gusts of smoke. Then she turned slowly and timidly crept to the pier. When she touched it, you could almost hear her sigh of relief.

For some time she rested beside the pier. Then suddenly she seemed to catch a second wind. Her cranes swung about like stiff, clumsy arms, picking up ammunition, grabbing big boxes of supplies, pouring more and more stuff out onto the pier, now rumbling with Army trucks. Somehow, as you watched her busily working, you grew fond of her. She became your own special ship. You saw her not as an old, slightly battered Liberty ship, but as a kind of symbol of home. And you liked to think of her as having been born in a great and proud shipyard, built of good American steel, put together by the men and women and children who, like you, were in this war to the end.

Now you look about the harbor, your eyes take in the whole unholy mess, and you wonder how they'll ever get the place to working again. You think of all the junk the Jerries blasted out and dumped in the water—the gantry cranes, the quays, the broken-down trucks and tractors and tanks. the walls of buildings,

and just about everything else they could lay their hands on. You remember there must be hundreds of ships on the bottom, choking up the channels. You think the job of putting that port back in shape is impossible, something only optimistic fools in their blind ignorance would attempt. Yet there was Cherbourg with its wreckage just as bad or worse than this, and they did the job in seventy days.

At Cherbourg the German commander had done his job of demolition so well that he had received a special decoration from Hitler. He had destroyed 95 per cent of the port, a feat none of the American and British Engineers had believed possible. Now, Cherbourg would have to handle four times as much tonnage as they had figured. It would have to be expanded to 25 times its normal peacetime capacity.

Our Army Engineers and Seabees moved in under the zinging of machine-gun bullets. And in the face of mines, booby traps, and sniper fire, they dug into the job. The Navy didn't have enough equipment, neither did the Army, so they used abandoned German equipment. They tore German mines out of roads and used them for blasting. They fixed and pressed into service German cranes, trucks, and power shovels. And they built docks with 10,000 barrels of German cement, stored for use in building a nearby rocket-launching platform, which, if completed, would have sent its terrifying missiles screaming down on British cities.

Soon the battle to supply Cherbourg with building materials and equipment became a crucial problem. Special trains were given the right of way to our East Coast, fast freighters were loaded at night in record time and pushed across the Atlantic faster than ever before. More material was rushed from England by boat and plane.

When our men had finished and their heavy, clumsy equipment was waddling off to other jobs, the Seabees and Engineers

paused long enough to add up some figures. They found they had used 514 pieces of heavy equipment, had driven 6,000 piles, and had consumed enough two-by-four lumber to reach from New York to Wyoming. They had built more than a half million square feet of timber-deck wharf, and a quarter million square feet of concrete-deck wharf. In 12 hours, their records show, they had thrown together a pierced-steel plank runway, 4,600 feet long and 120 feet wide; and then to add a little fillip to the whole thing, they had built two railroad yards. In doing it they dug and pushed around 350,000 cubic yards of dirt.

But the figures, big as they are, don't tell the whole story. They don't reflect the hair-raising job of removing mines and booby traps from an undersea jungle of smashed barges and twisted steel, the clearing of sunken ships and wreckage from channels, the little matter of sniper fire. Yet seventy days after the capture of desperately defended Cherbourg, our construction men were packing their tools and moving out. When they left, our cranes were tossing around 13,000 tons of supplies a day, about 13 times as much as the port handled in peacetime. Ducks and LST's were swimming more stuff ashore, and our troops were getting food and ammunition and all the rest.

Other ports, like Marseilles, Le Havre, Antwerp, and Rouen, were restored as they fell. In some, the job presented new problems. Some were tougher than others, but all were soon pouring supplies to our armies rolling across the continent. Before May 8, 1945, those four ports plus Cherbourg, Ghent, Port-de-Bouc, and Nice, unloaded more than 12 million tons of supplies.

In Italy, months before Cherbourg appeared in the communiques, before we even hit the Normandy coast, Naples was proving to be a foretaste of what was to come, and to the men doing the job the taste resembled that of a green persimmon. When our Fifth Army took Naples, the Engineers and Seabees saw that

our own bombs had caused about half the damage to buildings around the harbor. One big bomb had blasted a crater in the quay so big that, instead of repairing it, we used the crater as a harbor for small lighter craft. Our bombs had also sunk at least five ships and destroyed almost two-thirds of the bulk-oil-storage installations.

In addition, the Nazis had done their usual thorough job—blown up or scuttled 32 large vessels at the quays and piers, and sunk 300 smaller boats in strategic spots throughout the harbor. They damaged all cranes and dumped them over the edge of piers along with chunks of concrete and other junk. In the city of Naples they wrecked the main railroad lines, using an ingenious device consisting of a huge claw-like gadget mounted on the rear of a railroad car. This claw ripped up ties and, at regular intervals, dropped a delayed action charge along the track. They blasted all the railroad bridges, destroyed aqueducts bringing water to the city, and blew up all generating stations and power houses within a fifty-mile radius.

It soon became obvious that the battle to restore Naples as a big port was a battle between American and German Engineers. We were depending on our construction workers to rebuild what the Germans had so thoroughly destroyed. On how well and how fast they could do the job hinged, to a very considerable extent, the success of the Italian campaign—the battle against mud, mountains, and Jerries.

When the Krauts left they were sure the port of Naples was completely blitzed. You can almost hear the German engineers chuckling as they sank ship after ship. For instance, you can almost see them grinning smugly as they scuttled a hospital ship off the end of one of the piers. When our Engineers saw that ship lying on its side, its unusually flat bottom perpendicular to the water, they thought for a moment that here was another long job.

But soon, Yankee ingenuity hit upon a scheme. They simply ran a bridge from the pier to the scuttled ship. In a few hours our boats were unloading on the side of the ship and supplies were rolling over the bridge to the pier.

Another time, they ran pontoons out from quay walls so that Liberty ships could dock against improvised pontoon piers and unload their cargoes. At other times, they used sunken ships as foundations for piers.

In doing the whole job, they built ship berths, quays and warehouses. They dozed out roads, rebuilt railroads, restored sanitary facilities, got water and electric power into the city. They erected troop quarters, and they threw together big facilities for unloading, storing and distributing oil.

Three months after the Germans fled Naples, the port was handling more than the huge New York Port of Embarkation: in six months we unloaded about 2,350,000 tons, or a little less than the port had ever handled in a full peacetime year. In ten months, Naples hit the all-time high with some 5,350,000 tons of cargo.

Although pre-occupation estimates were for not more than 5,000 tons a day under war conditions, for a while they unloaded 20,000 tons a day. They unloaded it, they got it up through the mud and mountains, and they hit the Jerries with it.

But in addition to ports, we needed railroads. In France they had been bombed into a tangled mass of twisted rails, splintered ties, choked-up tunnels, and jumbled marshaling yards. It was the job of the Engineers to put them back in shape.

22

Steel Rails to Berlin

FIRST you blast the railroads to kingdom come, then you wade in and rebuild them. The better you are at the first job, the tougher the second.

In doing the first, you get in a bomber, lug along tons of eggs, and fly to your target. You make your run, sight, and lay your eggs as precisely as you can. You watch them falling, see great geysers of earth and steel rails and locomotive parts shoot up, and you know you've done your job. This doesn't mean it's simple or easy. You may have been in plenty of trouble. And maybe some day you won't fly back across the channel at all.

When you tackle the second job you are earthbound. You haul steel rails through mud, you sweat it out at river crossings with huge "I" beams and trusses, you bring in your big cranes and power shovels and bulldozers. And you work so hard that at times it seems you could sleep through a dozen weeks. But of course you can't sleep. The thing keeps reeling around in your head. Sheer nerve pushes your body ahead to the next bridge, the next marshaling yard, the next stretch of cratered roadbed, twisted track, and bombed-in tunnels.

You never quite get over the wreckage—a freight car tossed through a barn roof, a steel rail twisted like a corkscrew, a half-buried locomotive with its boiler tubes sticking out like soda straws in a glass. You see other locomotives, some on their broad backs, wheels sticking straight up in the air, others broken in two, and some minus cabs, wheels, and about everything else. You see

bridges with blown-out spans, track dangling down into the water. Sometimes the entire bridge is gone.

And while you are looking at it and wondering if trains can ever be made to roll over it again, you hear through the grapevine that 4,600 bridges are knocked out, that two-thirds of the engines in France are either destroyed or in dire need of repair, and that of 500,000 cars, only 140,000 are able to roll. The figures hit you between the eyes, for you know what they mean in terms of supplies—the job of getting gas, ammunition, food up to the front.

But the Army Engineers take it calmly, squinting professionally at the wreckage, pushing their dozers and cranes a little harder, but still being matter-of-fact about the business of rebuilding railroads in record time. Then they get word that General Patton, just a little way back from the coast, is yelling for gas and ammunition. If he doesn't get it in 48 hours his tanks will have to wait like so many decoy ducks while the Jerries romp away or wind up for counterattacks. It was one of those moments when anything might happen.

Plenty did happen. The Jerries must have known that Patton was in a bad way. They knew the 75-mile single track railroad into Laval and Le Mans was almost a jumble of track and smashed bridges and wrecked marshaling yards. And they probably knew that the only way we could get adequate supplies to Patton was over that railroad. Their experts had estimated that it would take weeks to get it going again. Indeed, in typical Kraut fashion they knew everything. That is, everything except the one all-important thing.

Our Engineers sized up the situation—found seven bridges knocked out, three marshaling yards blasted, service and water facilities smashed, miles of track wrecked. Forty-eight hours!

They tore into the job like Bengal tigers. They yanked their

dozers and cranes and power shovels from other jobs. They got all the trucks they could and a few more. Then they swarmed over that railroad.

The highways shook with their heavy trucks, groaning under the weight of big "I" beams, fabricated bridge sections, steel rails. For miles around they scoured the countryside for material. They kept right on through the night, their cranes looming up in the dim light like strange monsters, reaching down and picking up twisted rails, battered switches, splintered freight cars. Their dozers pushed away heaps of wreckage, filled in craters, and rolled dirt across the smaller streams.

At St. Hillaire du Harcourt they hit the toughest of all seven bridge jobs. This is the bridge over the Selune River. One end of its 100-ton truss span had been blasted to the bottom of the river, 15 feet below the bridge seat. It was also three feet out of line. The job was to lift a chunk of solid steel 110 feet long and weighing 100 tons out of the bottom of the river, move it three feet to one side, and fix it so trains could ride over. They didn't have pumps, so they couldn't build a dam around one end of the bridge and suck out the water for a jacking crib. They built the crib in water out of timber ties, about the same way you'd build a tower out of matchsticks. On top of the crib were placed two huge jacks. As the jacks lifted, more timber ties were put on, making the crib higher. All in all, they used 1,500 timber ties. Gradually the bridge rose out of the water. Then they used two enormous traversing jacks to push the bridge sideways and bring it in line.

The dead line was just a few hours away when trains loaded with gas and ammunition inched their way along the track, waiting here for a bridge to be finished, there for a stretch of track. By midnight on August 15 the locomotives chugged over the bridge at St. Hillaire du Harcourt and rumbled on down the line into

Laval and Le Mans. General Patton got his gas and ammunition. And he got them on time.

As our armies raced through France, the steel rails followed them. We threw bridges across the Seine, the Marne, the Meuse, the Moselle, and a hundred other streams. We cleared tunnels, laid tracks, built marshaling yards. And as we unrolled this ribbon of steel, the Germans became frantic. At times it must have seemed to them that they were being chased not by an ordinary, human kind of army, but by an army pushed relentlessly forward by steel monsters capable of cutting roads out of solid rock and bottomless mud, of lifting huge steel trusses and piers like so many toothpicks. Never before had Europe seen anything like it.

23

The Bridge Builders

Bridges were thrown up so fast that they eventually became routine construction jobs. Engineers became confident that no job was impossible. Some said, "Get us the materials and equipment, and we'll build you any bridge, any size, in almost any time." One Engineer even pooh-poohed the idea of having to be handed the materials on what he called a silver platter. "Hell, we'll build 'em without the materials. Just say the word, and we'll do the job with what we can pick up here and there about the blame country."

But he was a bit different from most. Possibly because of the gift he had received straight from heaven a short time before. He had faith, if you want to call it that, in his rabbit's foot and an old silver dollar he'd clutch when trucks didn't show up, or when a bulldozer started spitting weakly. Somehow, the charm always worked.

"The bridge work," he said, "had come to a stop. I rubbed my rabbit's foot and I squeezed my dollar, but still nothing happened. So I sat down on an 'I' beam and concentrated, trying to dig out a solution. It looked tough. We had to get that bridge up. But there wasn't any lumber for the forms. We looked all over the place, but there just wasn't any lumber any place. You know the feeling.

"Then, suddenly, I heard a weak rumbling sound way up the line, like a freight car that was on the loose and riding like hell. The noise was coming toward me and I got up and looked. At first I couldn't see anything, then I saw it bouncing and swaying

around the bend. It was coming fast, so I yelled and jumped behind a dozer. It kept coming, rocking and bucking down the line. When it got to our job, it lurched forward, ran on some loose track hanging out over the stream, jumped off the end, dove into the mud at the foot of an abutment, and threw a whole carload of lumber right where we needed it.

"Well, it seemed a bit strange. I knew the rabbit's foot and silver dollar weren't quite that good, so I looked into the matter. Several weeks later I found that the car had started miles and miles away, behind the German lines in front of a sawmill. This car was standing in front of the mill loaded with lumber. For some unknown reason it started to move. Then it gathered momentum and really got going. It rumbled and bounced on down the line, shot through a railroad yard like a streak of lightning, jumping switches, ducking other cars that were packed in the yard like a 'K' ration in its box. Then it came on down my stretch of track. And, well, you know the rest."

When they weren't blessed with luck, they took to improvising, and the results of their ingenuity were often enough to bewilder your methodical German Engineer. But the hair-brained schemes worked. Take, for instance, the de l'Arc Bridge over the Arc River near Aix. The Jerries had blasted out two arches, cutting the rail link to Marseilles, Toulon, and other coastal towns. There wasn't time to wait for a Bailey Bridge, one of those prefabricated sections which the British designed and which in many a previous crisis had saved the day. They didn't have enough steel. The job was urgent. So they took to the bushes, beating the surrounding country, searching every square foot for something that would do the trick. Finally, they found a captured German railroad gun, mounted on a 100-foot carriage—truly a beautiful sight to behold. They tore the gun off, tossed the pieces by the side of the track, and got the carriage up to the blasted

bridge. They launched the carriage over the two fifty-foot spans, took off the trucks, and lowered the thing in place. Then they laid track and had as nice a bridge as you could want.

Another time, near Metz, they had to have steel girders. As you know, you don't usually find steel girders propped up against the side of a barn or in grape arbors. They looked everywhere, but no steel girders. Then they heard there was a big one over on the wrong side of the German lines. So a crane man got in his mobile crane, drove over the line, picked up the girder from under a good many Kraut noses, and brought it on back for our bridge.

All during this time, in fact all the way from the beaches, everyone was thinking about the toughest bridge job of all—that last, final river. It was not just one more river to cross. It was THE river, the one river that would end all rivers. The end, they hoped, of a long, hard trail of mud and blood and utter weariness. No one was worried about it, everyone wanted to get to it and get it over with.

For centuries that river had stopped armies in their tracks, or permitted them to cross her treacherous currents only in mere dribbles. Caesar had stood on her banks and looked longingly across. Then, after almost superhuman effort, he had managed to build a pile bridge near Coblenz. Centuries later, in 1672, Louis XIV swam cavalry horses across near Tolhuys and built a pontoon bridge for more troops. Shortly after that another soldier, Marshal de Crequy, built a pontoon bridge and took Freiburg by storm. But these achievements were nothing compared to the job of getting railroad trains, tanks, heavy artillery, trucks, and hundreds of thousands of tons of supplies across the Rhine and on into Germany.

If, during the last two weeks of March, 1945, you had flown over the western approaches to the Rhine between Wessel and

Coblenz, a hundred-mile stretch, you would have seen a great flood of supplies moving up the river. In a never ending stream, over the railroads and highways, through deserted, gutted towns, over tree-lined country roads, poured the convoys. From the air they looked like ants struggling along in endless lines with bits of twigs and leaves and other burdens.

If you had flown lower you would have seen everything that could move loaded down with supplies—trucks, Ducks, tanks, trailers, all hauling supplies: pontoons and piles, lumber and gas, bridge steel and ammunition, crawler cranes and welding generators. The Navy's landing barges, manned by Seabees, and the Army's assault boats rumbled incongruously through barnyards and over little country lanes. And to the north you'd have seen the railroads, their steel fingers prodding through river valleys, reaching closer to the fighting front than railroads had ever been before.

Our supplies kept piling up for that biggest of all river crossings. And although it is not known just what the total quantities of Engineer supplies amounted to, estimates indicate we must have had 5 million board feet of lumber, 6,000 bridge pontoons, 4,400 assault crossing boats, and 2,500 outboard motors, plus 72 LCVP's (landing craft, vehicles and personnel) and 52 LCM's (landing barges). All in all, probably more than 100,000 tons.

The tempo of the crossing had been speeded up by a stroke of good fortune and by the quick, aggressive action of an Engineer officer turned tank commander. On March 7, 1945, Combat Command B was moving down from Bonn, clearing the west bank of the Rhine. At about 2:30 in the afternoon they passed Remagen, which is about half-way between Coblenz and Bonn. Then the unexpected happened. It was one of those things that may have shortened the war by months, may have thrown the

German Army so far off balance that their plans and reserves were almost useless. Their proposed defense of the east bank from that moment became extremely difficult.

For a minute, Combat Command B could hardly believe what they saw. The great Remagen railroad bridge was intact, waiting for them to cross. They investigated. A German prisoner told them the bridge was mined and would be blown up at 4 o'clock that afternoon. As they crossed, the bridge shuddered as one demolition charge went off, but they quickly yanked out and cut the wires to the other charges.

That one charge seriously damaged the bridge and it looked as if it would collapse. Disregarding this danger, our tanks went on across and before the Germans had a very clear idea of what had happened, we had a bridgehead on the east bank. By the end of the second day, we had ferries pushing back and forth across the river, a pontoon bridge built, and were hard at work trying to save the bridge. For almost nine days we fought to stop it from crashing into the river. But on the afternoon of the ninth day, the bridge trembled and with a roar fell into the river.

In the meantime, our supplies and bridge-building equipment were being massed on the banks. At Wesel, to the north, we would soon make one of the most carefully and elaborately planned crossings of the war. On March 22, 3,000 bombers blasted the German positions on the east bank. The following day, March 23, our artillery let loose with 1,250 guns, annihilating the enemy's river defenses. The next day, Army Engineers were in the wave of the assault boats, and had crossed the final major barrier to the heart of Germany. Five days later, after building floating bridges to establish a beachhead, they started a heavy-duty, single-track railroad bridge.

Bulldozers cut out roads. Fifteen pile drivers and steam hammers drove piles. Men spiked rails to ties, and cranes stacked

them up on trailers, ready to be pushed out on top of the bridge as soon as it was finished. Within a few days, giant cranes swung the trestles down on piles, lifted into position huge 'I' beams.

When it was finished, American construction men had built a bridge across the Rhine 1,732 feet long, plus a 463-foot section over a canal on the east bank, plus a fill 373 feet long—a heavy-duty railroad structure 2,568 feet long, just about a half mile. And they did it in ten and a quarter days.

Bridge followed bridge. We were in Germany for keeps. If the Engineers had looked back from Berlin and counted up what they had done since they landed on the beaches, they would have found that they had put into shape over 19,000 miles of single-track railroad, and had built or reconstructed 539 rail bridges, varying from small plate-girder spans to the major reconstruction of the 2,813-foot bridge across the Rhine at Duisberg.

In throwing bridges across the Rhine River barrier in breathtaking time, the Engineers made it possible for General Eisenhower to crush the German Army. His strategy, as revealed in an official statement from the War Department, "was to chew up as much of the German Army strength as the German Command would commit west of the Rhine; then when the die was cast, to plunge across the river in such force, such sustained force, that the Germans would be unable to regroup their armies in time to counterattack.

"The strategy depended on the ability of American Engineers to rebridge the Rhine, not just with tactical bridges but also with fixed 'line of communication' bridges capable of carrying supply trains across the river close behind armored thrusts. The Engineers were ready. Within six weeks from the time the Germans fruitlessly blew all bridges across the Rhine, except the one at Remagen, American Engineers had more bridge capacity spanning the stream than was in place before the Germans began their

demolitions. One 2,300-foot railroad bridge was constructed in six and a fraction days. Tactical pontoon bridges were completed across the river in less than 10 hours."

Still, the job wasn't done. There were the highways, the pipe lines, the airfields, the buildings, the canals, and all the other things a modern army must have to deliver the really hard punches.

24

Earth Changers

CAPTAIN Frederick J. Thompson of the 359th General Service Regiment stuck the three legs of his tripod in the dirt and sighted through the transit. He looked back and saw a dogface hurrying to him.

"Don't you know," said the dogface, "you're 500 yards in front of our advance troops? We haven't taken this yet. The General saw you—says you better get the hell back."

"Yeah, I know—but we gotta get this line through. Men are laying pipe right on my tail. We can't stop for Jerries."

And that's how they pushed miles of pipe across France. They snaked pipe lines forward on the heels of racing tank columns. In North Africa, they laid it at the rate of 20 miles a day, and in France they did it so fast that sometimes they felt the sting of German machine-gun bullets. Sometimes, they even worked in front of advancing troops.

When they had finished, they had laid 1,300 miles of 4-inch and 2,300 miles of 6-inch pipe. They had set up 176 pumping stations and put together enough steel tanks to hold 5,440,000 gallons of gas. At one time 1,500,000 gallons a day poured through their lines, an amount equal to the capacity of 1,000 big gas trucks.

Around on the other side of the world, other Engineers built the world's largest military pipe-line system; ran it over mountains, down river valleys, through jungles, under rivers, and over bottomless chasms. The India-Burma-China pipe line ran through

Bengal and Assam provinces in India, across northern Burma to Kunming, China, and beyond. They laid about 3,280 miles of pipe; laid it at the rate of 3 miles a day when the going was tough, 10 when they had fair conditions.

At one spot on the Brahmaputra River they sweated through a 8,200-foot submarine crossing. At another location they supported one-tenth of a 20-mile stretch on cables. Sometimes they had to cut trails around steep mountains so that they could bring in their pumping equipment. In some places in the China section they scaled mountains 9,000 feet high. At another place, they dismantled a whole pumping station and had it carried on the backs of natives through the jungle. Then they reassembled it on location. Yet they built the pipe line ahead of schedule, and it poured gasoline deep into Burma and China, releasing, for other purposes, hundreds of trucks on the Burma-Ledo Road and much of the air transport. Part of their pipe-line system serviced the Hump cargo-lift fields in Assam, providing bulk gasoline for cargo over the Hump to China.

Besides pipe lines, there were the highways. Over the roads the Engineers rebuilt and maintained in France—the "Red Ball," the "White Ball," and the "Green Diamond"—rolled an average of 6,500 tons a day. Heavy trucks rumbled over these routes night and day, enabling our armies to strike harder and faster. All in all, they put 4,000 miles of roads into operation, built 145 major highway bridges.

No matter what they needed, they built—everything from harbors and railroads to a thumbscrew on a ruling pen or a handle for a saucepan. They set up huge depots and shops. They put into operation 19,000 single-track miles of railroads for military use, threw bridges across Europe's widest rivers, built 72 landing strips, 277 fighter fields, and 107 heavy-bomber fields. They strung 1,900 miles of power-transmission line and

laid about 30 miles of water mains, built and rehabilitated accommodations for a million troops. They provided hospitals with a total capacity of 125,000 beds, which is about the number of hospital beds in Ohio, Florida, Maryland, Oregon, Virginia and Nebraska. And to top it off, they built depots covering some 230 million square feet, which is equivalent to an area a mile wide and about eight miles long.

The statistics kept piling up—hundreds of bridges, thousands of miles, millions of square feet—yet they worked on, building, pushing their heavy equipment close behind the dogfaces. You felt as though all the construction skill in America was being concentrated in one small area with a single objective—to wipe the Nazis off the earth.

Sometimes they took time out to fight. On the night of December 17, 1944, for instance, the Germans smashed hard east of Bastonge. Von Runstedt was riding high, wide, and handsome through the Battle of the Bulge; at least he thought he was. The Engineers met the attack head on. They fought back, blow for blow. They held firm. They did it for two days, even though it looked hopeless. Then the 101st Airborne moved in for its courageous stand.

The Engineers fought hard. One was Pvt. Bernard Michin of Providence, Rhode Island. One night he hugged his foxhole, staring at a cautiously advancing German tank. The tank rolled closer and closer. But he withheld his fire. Then at only 10 yards, and realizing the blast might destroy him along with the target, he let loose with his bazooka. The tank burst into flames. Blinded and burned by the explosion, Michin crawled from his foxhole, now raked by machine-gun fire. Still blinded, he listened intently and located the gun by sound. Then he dragged himself forward, toward the gun. He drew back his arm and with all his remaining strength heaved his hand grenade.

Some Things the Army Engineers Built or Reconstructed in Europe

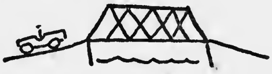
PIPELINES

3,600 MILES

ROADS

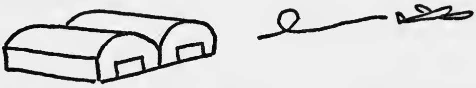
4,000 MILES

BRIDGES



680

AIRFIELDS



384

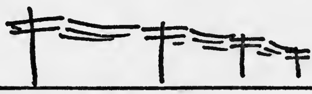
STORAGE DEPOTS

230 MILLION SQ. FT.

RAILROADS

19,000 MILES

POWER LINES



1,900 MILES

HOSPITALS

125,000 BEDS

Private Michin doesn't say much about what he did, in fact he'd rather not talk about it. But his citation for the Distinguished Service Cross reads: "with complete disregard for his own safety, he hurled a hand grenade and silenced the gun and killed the entire crew."

Up where the going was tough, you never knew. Maybe you'd be building another bridge or cutting out an airfield, or maybe you'd be taking pot shots at the Jerries. But mostly you'd be building and there wouldn't be much excitement, not much to be scared of, just the same job of making things.

The job of clearing out and putting in shape the inland waterways is a good illustration. In Belgium and southern Holland, they moved into the job of cleaning out the Albert Canal. The Jerries had left it filled with wrecked bridges, smashed locks, sunken vessels, and just about everything else they could lay their hands on. The task of getting this supply line back into operation was divided between British and American Engineers. In our sector, we yanked out 60 bridges, put locks in order, built new bridges. We dragged captured German equipment to the job, hauled steel girders from a captured German mill in Luxemburg, cut lumber out of a nearby Belgium forest. We tackled other canals, repairing and putting back in operation 800 miles of inland waterways for the movement of bulk supplies.

In the United Kingdom, months and months before we landed on the Normandy Coast, bombers and fighters were taking off from fields built by the British and American Engineers. From the Eighth Air Force's first heavy-bomber attacks, on August 17, 1942, to V-E Day, we rained down more than a million and a half tons of bombs on western European targets, pulverizing German industrial centers. To Army Engineers this meant hundreds of airfields, storage depots, roads, thousands of buildings, hospitals, workshops. The stout little island was turned into a

fortress swarming with planes, teaming with troops, bursting with supplies.

Studding the island were more than 500 airfields covering 250,000 acres. Sometimes the fields were built around small villages, and the runways, dispersal area, and connecting roads wove about and through the village. Bombers loaded down with their deadly missiles roared past while villagers went about their unruffled existence. Airfields were everywhere. We built them on filled-in swamps, cut them out of gently rolling hills, spread them over plowed ground and on green pasture. Entire farms were almost completely covered with two-foot-thick concrete and asphalt runways. There were so many of them, that one American pilot remarked, "If you're up 8,000 feet and your motor goes dead, you can always land on an airfield, and a good big one, provided the weather is clear enough and you can see the ground."

In building the fields, our British allies provided all the materials and most of the labor. The job required plenty of both, for we obtained roadways, perimeter tracks, and hardstandings in such great numbers that if turned into a twenty-foot highway, they would reach from New York City to Moscow.

The job of turning the island into a launching ground for our offensives was begun two years before the invasion. It involved the construction and acquisition of more than 100,000 buildings in 1,100 English villages and cities. The amount of work done by the Engineers was equivalent to the work of 15,000 men working throughout their entire lifetime.

Before D-Day, the Engineers had remapped France, Germany and the Low Countries. And before we hit the beaches we knew just where the tide would be, the location of Kraut defenses, the height of the waves bucking our assault boats. We had taken soil samples along the beaches months before and knew whether or not the sand would support our heavy equipment. We even

knew the location of just about every gun port along the German West Wall. These maps, the most accurate ever made for military operations, were prepared, printed, and distributed by the Map Service of the Army Engineers. For the invasion of France alone, they made 116 million military maps, enough to fill more than 200 freight cars.

And so the story goes. They were all over the world—in North Africa, the Middle East, the Pacific, India, Burma, the Atlantic. Everywhere they did much the same jobs. And every job, in one way or another, enabled us to strike harder and faster than any army had ever struck before. The amazing speed with which they built railroads, airfields, harbors, caught the enemy off balance time and time again, and was a potent factor in hastening the victory.

In the process, it soon became obvious that this war was also a war against dirt. The side that could push around the most dirt the fastest had a tremendous advantage. Through the Army Engineers and the Seabees was launched a construction program of almost undreamt-of magnitude. This program was based on American construction know-how, planned by the construction men of the country, and put into operation by our construction workers who were in the Army and the Navy.

25

The Navy Strips for Action

But there was much more to the war construction job. There was the huge construction program of the Navy. Even grizzled old sea dogs must have been a bit startled by what was created. After all, a navy was a navy, a fleet that could sail out and sweep the enemy from the seas, bombard his ports, raise hell in general. But this navy was different. It was hundreds of bases strung throughout the world, thousands of combat planes, more than a hundred dry docks, entire cities, and a fleet including some of the strangest craft ever to touch water. It was more than that. It was bulldozers and cranes and some of the toughest landlubbers ever to squint at the sun.

For a good many years the higher brass knew the Navy for this war would have to be different. But it is doubtful that they, or anyone else for that matter, ever visualized a navy of 91,200 vessels, a naval air force of more than 40,000 planes, and a personnel of 3.3 million.

Such a navy meant construction on an unprecedented scale —the building from July, 1940, to July, 1945, on a dollar basis, of 63 times more than in the First World War, and more than 33 times as much as in the 21-year period, 1916–1937. It meant an $8-billion construction job.

This doesn't include the cost of building naval vessels; it is the amount the Navy spent for constructing naval bases, ordnance plants, hospitals, training stations, and a multitude of other shore installations, all essential to the operation of the

Signa

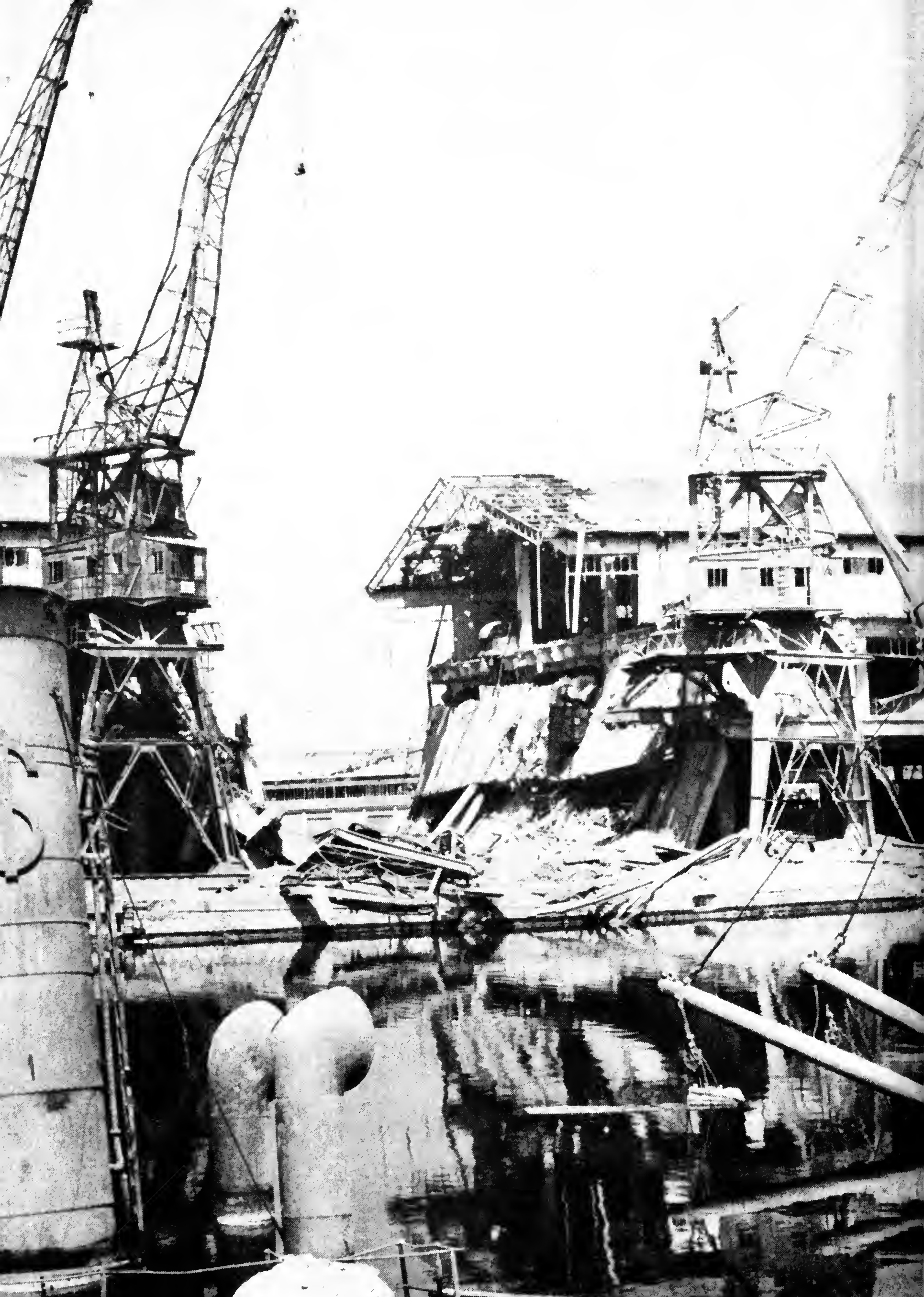
The Army Engineers swept out the mines . . .

Signal

tore the teeth from tank traps . . .

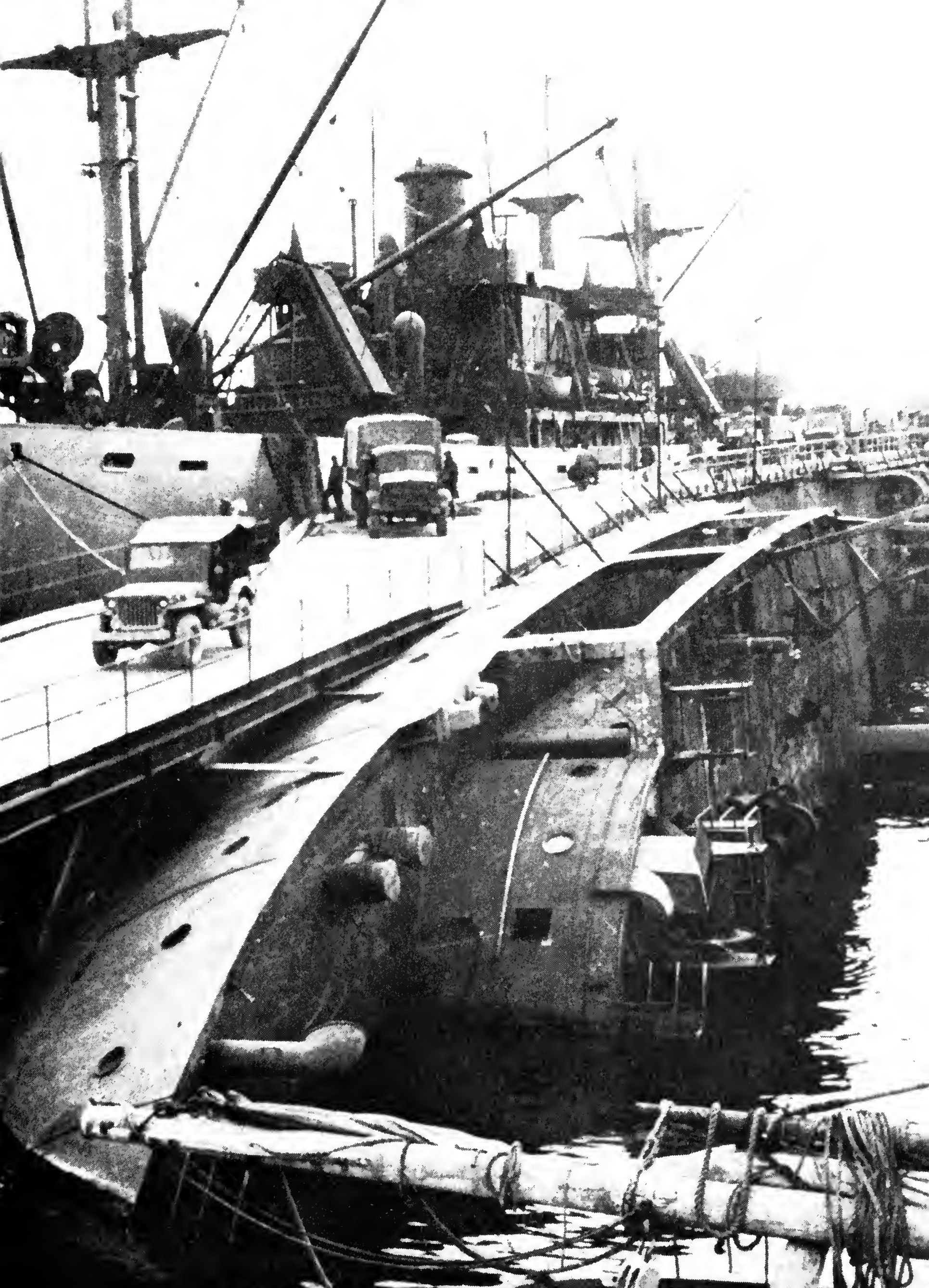
Signa

laid the pipelines.



Signal

They restored the ports . . .



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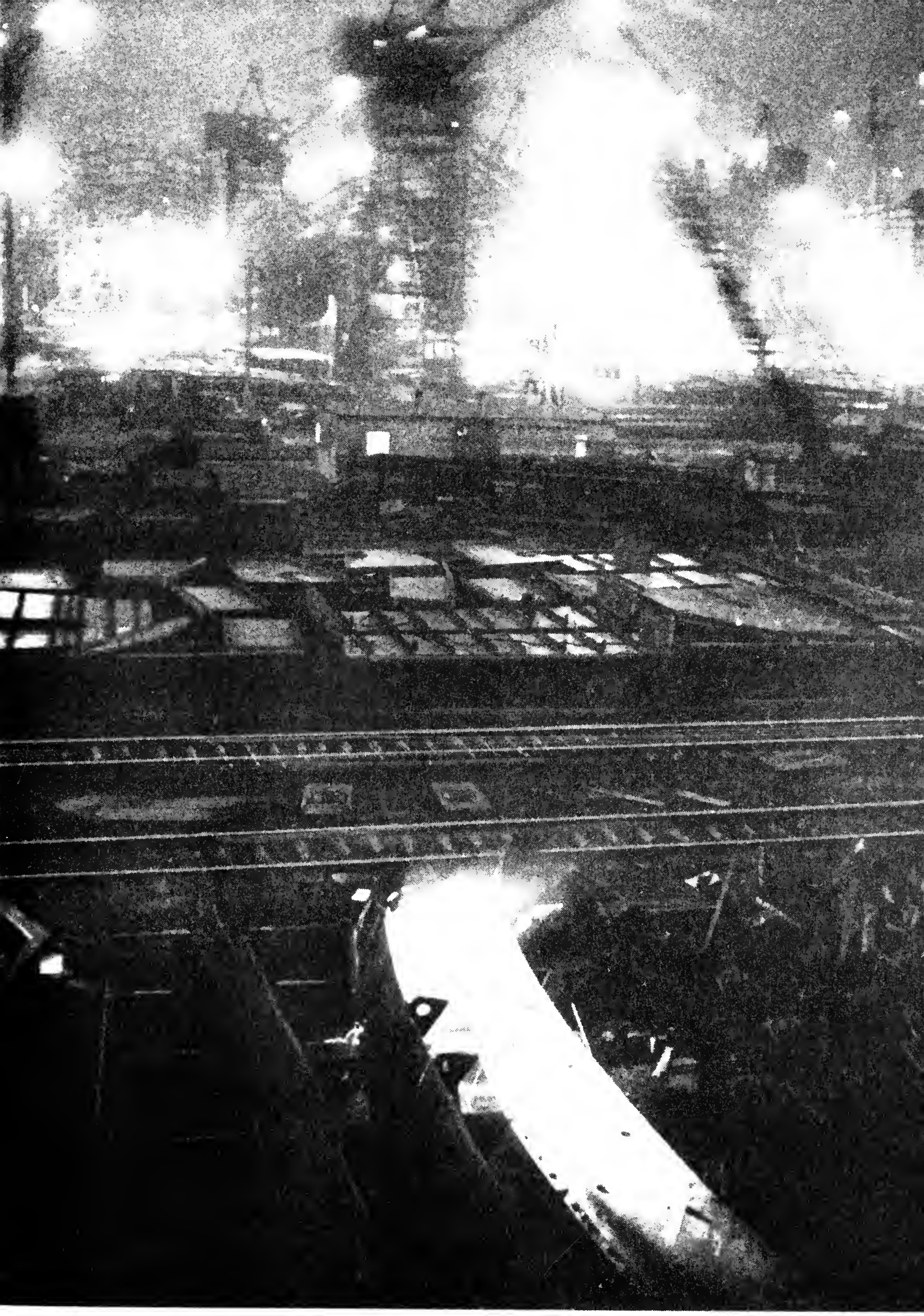
Signal (

rebuilt the railroads.

Sign

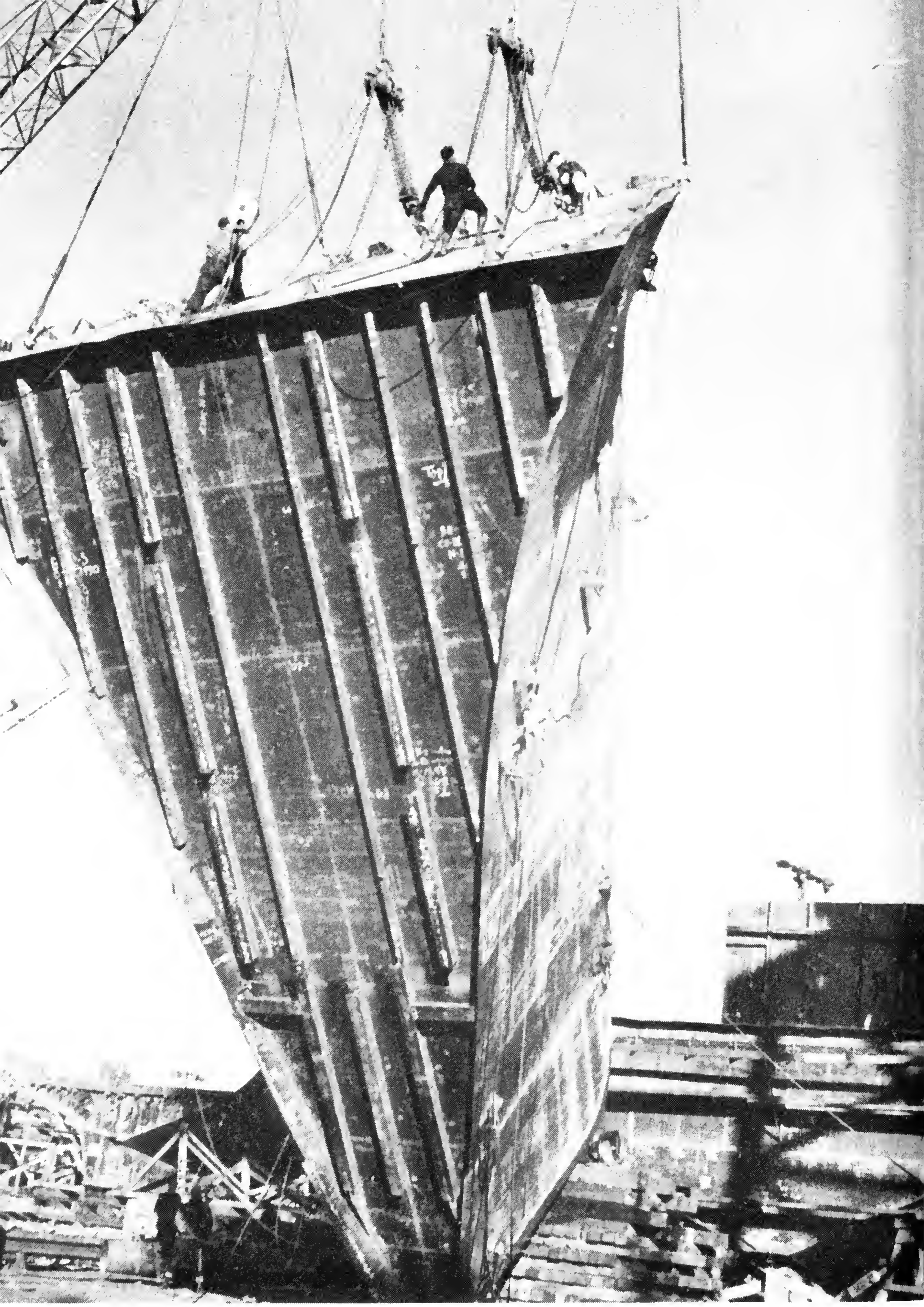
Signal

They chased the enemy with bridges and roads and airfields.



Library of

Night and day they built ships.



U. S. Maritime Commi

They lifted the ship's sections . . .

hoisted her deckhouse . . .

U. S. Maritime Comm

rode her propellers . . .

U. S. Maritime Co

welded her innards.

And their ships flooded the oceans . . .

U. S. Navy

U. S.

to spit steel at our enemies.

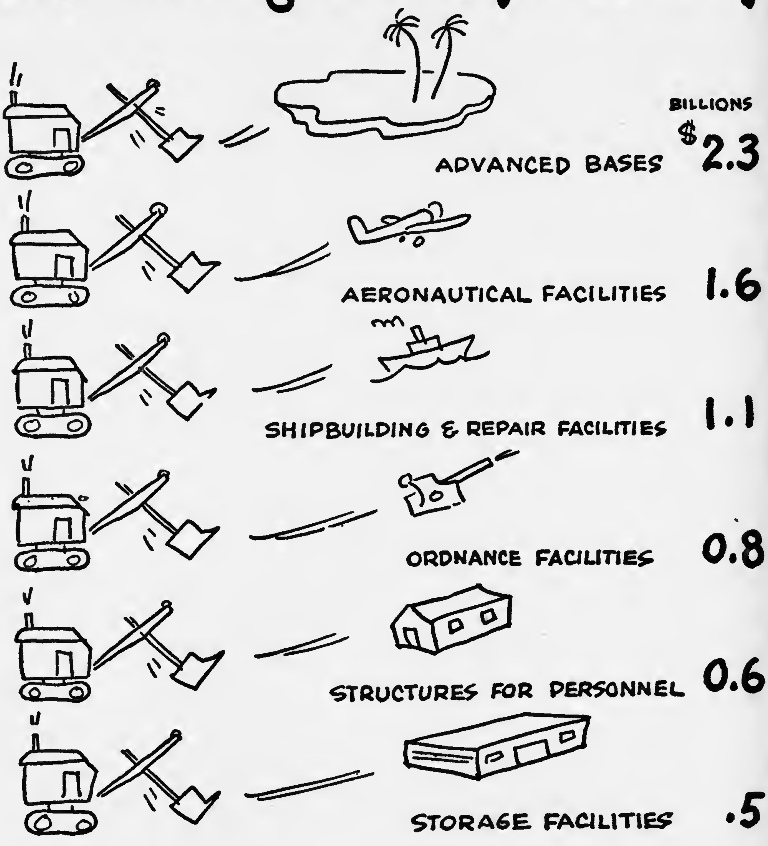
world's largest navy and, in one way or another, involving some of the toughest problems ever faced by contractors and engineers.

Included in the $8-billion figure are our advanced bases, some of them built by private contractors, but mostly done by construction workers in the Seabees. The money we spent for these bases amounted to more than $2.2 billion. For it we got those powerful, hard-hitting strongholds that enabled our planes to smash Japanese cities and our fleet to strike harder and faster than any other navy. At some of these bases our submarines, which destroyed, in addition to many combatant ships, about two-thirds of all the enemy's merchant shipping lost during the war, were repaired, refueled, provisioned and sent out again and again on their deadly missions. Some of the bases provided nests for our superforts, some had extensive facilities for repairing large vessels and for storing food, ammunition, oil and the enormous number of items needed by a modern navy before it can so much as turn a propeller.

Bases of this kind are, of course, more than tiny atolls. They are lethal cities in themselves. Many have miles of modern highways, extensive docks, miles of runways, repair shops, endless rows of barracks, rest camps, dry docks, tank farms, and a multitude of other facilities. They are costly and difficult things to build, and they were as essential to the fleet as aircraft carriers and battleships.

Next to constructing bases, our biggest building job was for aeronautical facilities which cost the Navy about $1.6 billion. Among other facilities, we built 80 air stations and numerous satellite fields, 38 of them at a cost of over $10 million each. One of them, the Naval Aviation Training Center at Corpus Christi, Texas, sprawls over 40 square miles and is the largest station of its kind in the world. In this $90-million unit are a

Some of the Biggest Construction Jobs Done for the Navy



main station, six auxiliaries, and 45 satellite fields. It includes housing for almost 30,000 officers, cadets and enlisted men—a city with a population equal to that of Hutchinson, Kansas, or Ann Arbor, Michigan.

Another big Navy construction job involving more than a billion dollars was the building of shipbuilding and ship-repair facilities. These yards and shops and dry docks, along with others, were responsible for turning out 1,200 combat ships, including 10 battleships, 27 larger aircraft carriers, 110 escort carriers, and 48 cruisers. Thousands of other vessels were built.

Our floating dry docks accounted for about $400 million. At the birth of the national emergency we had just three of these docks. Their total capacity was 40 thousand tons, hardly enough to serve a very small fraction of our war-swollen fleet. It was obvious that many of our ships would be blasted by the Japs and many more would suffer from the toughest kind of usage, have to remain at sea for long periods, and travel at highest possible speeds for weeks at a time. The cheapest and quickest way to add a ship to the fleet was to repair our tired ladies, patch up the battle wounds of others. To do this we had to have plenty of hospitals close to our girls. So we built floating dry docks, 155 of them, with a lifting capacity of more than one million two hundred thousand tons. They more than earned their cost, servicing about 7,000 ships, including the biggest battleships in the world, during the last year of the war. The importance of the speed with which shipbuilding and repair facilities were completed cannot be exaggerated. Its contribution to the war is, perhaps, best stated by Fleet Admiral Ernest J. King, Commander in Chief, United States Fleet, and Chief of Naval Operations.

"The destruction of the Japanese Navy," he says, "followed the Nelsonian Doctrine that naval victory should be followed

up until the enemy fleet is annihilated. Of 12 battleships, 11 were sunk; of 26 carriers, 20 were sunk; of 43 cruisers, 38 were destroyed; and so on throughout the various types of ships, which collectively constituted a fleet considerably larger than ours was before the war began. The few ships that remained afloat were for the most part so heavily damaged as to be of practically no military value.

"In striking contrast is the record of our ships. Although 2 old battleships were lost at Pearl Harbor, 8 new battleships have since joined the fleet. Against 5 aircraft carriers and 6 escort carriers lost, we completed 27 carriers and 110 escort carriers. While we lost 10 cruisers, 48 new cruisers have been commissioned. We lost 52 submarines and built 203. The capacity of the United States to build warships, auxiliary ships and merchant ships, while supporting our forces and our allies all over the world, exceeded all former records and surpassed our most sanguine hopes. It proved to be a vital component of that sea power which Fleet Admiral Chester W. Nimitz has well defined. . . ."

Another major construction job for the Navy was the building of ordnance facilities. These Navy plants to turn out the bombs, shells, guns, and so forth, cost us about three-quarters of a billion. Some idea of the extent of the ordnance program can be gained from the fact that during the five years, 1940–45, we increased the rate of firepower on naval guns installed on ships from 411 tons of projectiles to 4,500 tons per 15-second period. It was this kind of firepower that enabled us to hurl some 16,000 tons of steel at Iwo Jima, and almost 50,000 tons at Okinawa.

All down the line we built to build a Navy. The strength of the Naval Air Force grew from 1,741 planes to more than 40,000 planes, personnel jumped from 161,000 to 3,390,000,

naval vessels of all types from 4,500 to more than 91,000. And every increase, regardless of its kind, whether it was in the number of hospitals, storage facilities, housing for Navy personnel, or radio facilities, meant more and more construction. The program extended to the uttermost reaches of the earth, but it was largely concentrated in the Pacific, from the Aleutians to Australia, from San Francisco to Okinawa. It involved the Panama Canal, the British Isles, the Middle East, and Africa. It overflowed in hundreds of shipyards strung all the way around our coast, and its plants were found in a thousand inland towns as well as in our big industrial centers.

26

Pacific Stepping Stones

THE building of our island bases was one of the toughest construction jobs ever undertaken by contractors. We built them throughout the world, in temperatures that dropped to 70 below, on ice 12,000 feet thick, in the teeth of winds that cut through you like a million flying needles. We built them in jungles where the heat soared to 120 degrees and 200 inches of rain poured down in a single season. And in doing the job we actually heaped an island out of the sea, sliced off the tops of mountains, made harbors where only wind-swept coast existed before, and turned many a pimple of an island into a hornets' nest of buzzing planes.

We started the job back in 1939 when Congress authorized the building of bases in the Atlantic and Pacific. At first, in the Pacific, we concentrated on eight bases: Kaneohe on Oahu, Ford Island in Pearl Harbor, Johnston Atoll, Midway, Wake, Palmyra, Kodiak, and Sitka. The job soon rolled up into a far-flung series of bases extending all the way across the Pacific to the Philippines. The distances alone were vast enough to make any contractor hesitate—that is, any contractor who realized the difficulties involved in shipping hundreds of thousands of tons of bulldozers, cranes, lumber, dredges, cement, over thousands of miles of ocean, then on many jobs having to unload the cargoes on lighters. Not only this, there were personnel to be transported, and every stitch of clothing, every spoonful of food, every glass of water, everything it takes to enable the human

animal to exist on remote and barren pinpoints of land two and three thousand miles from home.

On dozens of these islands we cut channels through the coral reefs, built seaplane ramps, airfields, tank farms, repair shops, hangars, piers, barracks. On some of them the coral was so tough we had to blast it out, sending down divers with sticks of dynamite in their teeth. They'd plant the explosive, swim up to the surface for blasting caps and wiring, then dive again. After the dynamite was all wired and ready, the launch would putter away to safety, and soon you'd see geysers of water roaring up out of the lagoon and hear the dull booms as charge after charge went off. Then the big dredges and heavy dump scows plowed in. The big mouths of dredges would sink wide open into the loose coral, bite, and with a puffing and a whirling lift it up to the top, swing over a dump scow, and let it roar down into her. Endlessly this kept up, day and night, dredging millions of mouthfuls of coral and muck, until the channels and lagoons were deep enough for ships.

But first, almost always, they had to blast a small channel through the reefs to get men and supplies on the beaches. They did this by wading waist deep over the reef and setting their charges under water. As soon as it was deep enough for a small boat, they'd start hauling stuff through the surf. Gradually the channel grew deeper until finally big ships could get in.

Often the job of unloading became a major problem. At Midway, for example, they had to unload their equipment in heavy seas. It was hard, dangerous work. While tugs held the bouncing lighters close to the high steel walls of the ship, cranes swung over tons of cargo. Then, just at the right moment, the stuff was lowered into the lighters which were moving up and down in the heavy sea. If you missed, if the lighter was thrown hard against the ship, if you were thrown overboard, or an arm

or leg slipped between lighter and ship, you might live or you might not. It took them four weeks to unload four thousand tons of cargo—four weeks of sickening spins as the cargo plummeted down at them, four weeks of trying to hold their balance on a slippery deck that heaved and tossed like a cigar box.

On this barren spot of walking sand dunes they soon came face to face with thousands of the original inhabitants, those curious birds, the goonies. The birds led the existence of Riley, for Washington had sent word that under no circumstances were they to be hurt. They strutted about the island supervising the construction job so closely that for a while a man had to walk in front of every dozer, talking and arguing and trying to persuade them to move out of the way. But the goonies must have known their rights. They were stubborn, and it took time to shoo them away, so much time that finally the dozer men ran over them. But the stench became unbearable. So they had to be picked up one by one and hauled away. After the landplane runway was built, the goonies persisted in believing it was built for them. They got in the way of our fliers, were always fussing about the planes, became a dangerous menace. The Navy declared war on them and set out to liquidate the whole colony. The goonies eyed our attacks with some trepidation, finally got the idea, and stayed away from the planes.

On Midway, as on all remote island bases, it was the monotony and isolation that got you more than anything else. You didn't mind the work, your quarters were clean and neat, your food excellent, but your spare time almost drove you crazy. Day in and day out, night after night, month after month, all you heard was the endless roaring of the sea, beating and pounding in your ears. Most of the time you worked in a cold hard wind. You ate, slept, and worked in the dripping dampness, fought continually to get your stuff ashore, and watched

the goonies strutting about. After a while you never wanted to see the place again, you became fed up with sand, ocean, wind, and surf. You became so lonely that bars, nightclubs, and women seemed to exist only on the moon. And a family with a mother, roast-beef dinners on Sunday, and real live kids, seemed like something from heaven.

The importance of base construction at Midway is indicated in one of the Navy's press releases: "The contract for the improvement of defenses at Midway," the release states, "was awarded in August, 1939. The original estimated cost was $3,750,000. The contract date for completion was in August, 1942. The Battle of Midway started June 3, 1942. By that date there had been completed, on Midway, work to the value of $19,795,000—about five and one-half times the original program, and in less time than the original schedule calling for $3,750,000 worth of work. Construction obviously is less spectacular than battle action, but the value of the Midway installation is proven by the strategic importance of that victory."

Palmyra, another island base, was as different as it was lovely, a veritable little paradise of emerald-green lagoons, great palms with curving trunks, and tiny islets strung about like pearls on a necklace. It nestled in its ring of sparkling white surf like something out of a Hollywood romance of the South Seas. It had everything, a tropical moon over the ocean and starlit nights and a white coral beach. One almost expected to see Dorothy Lamour.

But Palmyra also had its problems, and not the least of them was the rain. About two hundred inches of water, some 16 feet of rain, poured down every year. In the steaming dampness, shoes started to fall to pieces after a few weeks; belts and other leather goods usually were rotting after a few months. To stop machines from rusting overnight, they had to smear them with heavy

grease. Even the highest grade steel pipe lasted only a year, rotting away in the ground as though made of paper. And trucks were good for less than 2,500 miles.

The combination of rain and coral with its high lime content produced a powerful alkali that devoured any metal coming in contact with it. It ate through steel and threatened to turn machines into jumbled piles of junk. So they invented a kind of glorified shower bath to fight it. They buried this contraption in the floor of one of their sheds, drove their machines over it while the shower sprayed their dozers, trucks, and other equipment with rust-resisting oil. Every morning they did this on their way to work.

Other islands felt the bite of their clamshells and the endless pushing of their dozers; all the way from the frozen, fog-shrouded Aleutians down to the Samoans, from California to the Philippines, they built a network of bases so that our fleet and army could drive the Japs back and so that our planes could hammer home some of those knock-out punches we had been waiting so long to deliver. At first they built to defend us; after Pearl Harbor they built to strike back in the biggest of all naval offensives.

Before the end of 1940 contractors started studding the island of Oahu and other islands in the Hawaiian cluster with the world's most complete system of bases. The job included every type of installation—waterfront improvements, complete naval and air stations, new radio stations and ammunition dumps, a rifle range, a full-size submarine base, and an enormous housing project for naval officers. But their most spectacular job, truly an amazing project, was the building of the underground tanks for fuel storage at Pearl.

On the day after Christmas, 1940, dozers and scrapers started digging into Red Hill. They cut their roads down the hill to the

harbor, hauled up lumber, mixers, air compressors and all the rest. The idea was to hollow out the inside of the hill until it resembled a gigantic anthill. It would be cut through with galleries and honeycombed with steel-plated vaults approximately a hundred feet in diameter and about as high as a twenty-five-story building. Each vault would hold many thousands of barrels of oil and altogether contain enough fuel oil for the entire Pacific fleet, some six million barrels. In addition, there would be pumps, a complicated system of valves and controls, blower fans, surge tanks, powerhouse, and all the other paraphernalia needed for getting the oil in and out. All this, of course, also would be underground.

The first job was to drive two tunnels at different levels into the hill, then to sink a shaft about three hundred feet deep which would connect the two ends of the tunnels. After the shaft was made, they widened it. The rock and dirt fell down the shaft to the bottom tunnel where conveyor belts caught the rock and carried it out to daylight where it was graded and crushed, much of it being used in making concrete for lining the vaults.

As shaft after shaft was cut down through the rock, they ran in more tunnels, more conveyor belts, some of them 48 inches wide and tough enough to carry chunks of rock four feet in diameter. The nearly 8 miles of conveyor belts ran in all directions, and from the time the rock broke loose until it arrived outdoors no one touched it.

After they had driven their holes down through the rock, they built the skeletons for their tanks, great cylindrical affairs some 250 feet high. Then they fastened steel plates to the framework, welded the plates together, and poured concrete between the finished tank and its nest of rock. This gave you what amounted to a series of steel-lined cylinders embedded in solid rock. The tops of these cylinders were sealed with steel domes;

pipes, valves, pumps, and so forth were put in and the vaults were ready. Over the top of the enormous cavern with its vaults and galleries was a hundred feet of concrete and earth.

Even though they finished the job nine months ahead of schedule, it took them two and a half years; the Pearl Harbor attack caught construction workers still building. After the attack, they had the job of cleaning up the smoking ruins. Nine thousand of them pitched in to help the Army and Navy throw up defenses. Metal cutters swarmed out over the bottom of the overturned *Oklahoma* and cut through her plates to rescue her trapped men. They helped get our boats up from the bottom and blasted moorings to free some from wreckage. They built bomb shelters, strung barbed wire around ammunition-storage yards, poured concrete revetments, dug tank traps, prepared mine-field areas. They filled two million sand bags. And they yanked all the guns they could lay their hands on up to the summit of Ulupau—one of them was a one-pounder with "1898" stamped on its breach.

From the time the last Jap plane roared out of sight, they worked furiously. Everything that could float was pressed into service to haul desperately needed cement, steel, equipment, and supplies from the States. Now it was not a question of building bases that someday would be needed; it was a question of either building fast and well or of letting the Japs turn the Pacific into their private lake.

They knew what that meant. On Guam and Wake, the Japs had swaggered ashore, beating, kicking, and bayoneting civilian construction workers. They killed or sent to the filthiest prison camps in the world some 1,200 men and women.

The construction job at Pearl doubled almost overnight. We needed and built an endless variety of military installations. Docks were built along some 5 miles of shoreline, housing

projects popped up out of the earth like mushrooms, and the islands became a nest of airfields, tank farms, personnel shelters, tank traps, dry docks, ammunition igloos, warehouses, hospitals.

With tremendous quantities of explosives arriving from the States, storage soon became a problem. To take care of our shells, bombs, torpedoes, and powder, they turned the inside of a hill into a vast arsenal, driving 120 horizontal caverns into a solid-rock wall. Each cavern was about as high as a small house and 200 feet long. They built some 6 miles of them along with the necessary railroad facilities. By this time the underground work had grown to such proportions that most of them felt like tin-hatted gophers.

They pushed their construction work to the peak of a mountain—a sheer climb with pick and rope and spikes up into the clouds—to build the aerial for a radio sending station capable of reaching every square mile of the Pacific, the Indian ocean, and Australia, and submarines resting on the bottom of Tokyo Bay. The climb took them twenty-one days and when they reached the summit, some 2,800 feet above the sea, they were wrapped in cold and dripping mist and could not see more than 20 feet about them. Then they yanked up their equipment and steelwork and built the towers for their aerials, spinning the wires across the Haiku Valley.

On one island job, a top secret at the time, they started with a piece of land about as big as a good-sized victory garden. This desolate pinpoint of earth, called Tern Island, is between Midway and Oahu. It was hardly big enough for a plane to sit on, much less land and take off. Yet we had to have a naval air station out there in the middle of the ocean if we were to fly "hot" fighter planes from Pearl to Midway, a distance of 1,300 miles.

The only solution was to build an island, so the Navy asked the contractors to make one big enough for a landing strip 3,100 feet long and 250 feet wide. They brought in the big dredges and started lifting an air station from the bottom of the ocean, biting in the shoals of the lagoon until they had lifted and piled up 660,000 cubic yards of coral and muck. Then the Seabees took over and spread it out and rolled it down hard and put on the finishing touches.

That's the way it was, digging islands out of the bottom of the ocean, burrowing like so many moles through mountains, climbing sheer rock walls into the clouds. It sounds spectacular and in some respects it was. But mostly it was a matter of sweating it out, fighting malaria, monsoons, loneliness, and vast distances. They did this for more than four long years, from 1939 to the end of 1943. Some of them were beaten, some clapped into filthy prison camps, some bayoneted and killed, but all of them helped build the sea roads for our Navy and Army.

27

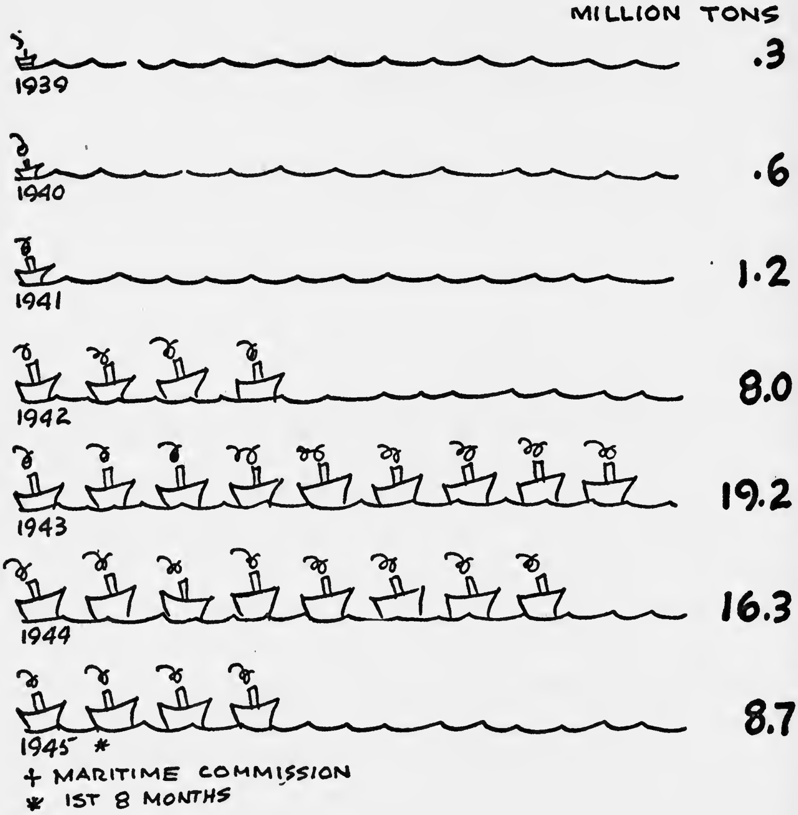
Freighters for the Seven Seas

For a while it looked as though our lack of ships might cost us the war. Then it was not a fantastic fear. It was real, as real as a bayonet in your back. In the 15 years from 1922 to 1937 we had produced exactly two ocean-going cargo freighters. Between the start of the war in Europe in 1939 and V-J Day we lost about 6.5 million dead-weight tons, a good deal more than half our entire prewar merchant fleet. In May, 1941, the rate of Nazi sinkings of merchant ships was more than three times the capacity of British shipyards to replace them, more than twice the rate of the combined British and American output at the time.

We eventually whipped the submarine, but we had to have ships, and we had to have them fast. They are hard things to build. In the First World War the best we could do was to launch them six months after laying their keels. At the time, experts believed that record could never be broken. As of March, 1942, it looked as though the experts might have been right, for it was taking us an average of 228 days to build a 10,500-ton Liberty ship. It wasn't fast enough.

In 1939, we had only 10 yards with a total of 46 ways capable of turning out ocean-going vessels 400 feet long or longer. Building more yards and ways in record-breaking time was the first job. Our construction workers swarmed out along the coast, their big dredges digging channels, their concrete mixers churning prodigious quantities of sand and gravel and cement and

We Built 54.4 Million Deadweight Tons of Ships+



water, their giant pavers spewing the stuff out over hundreds of acres. They tossed up huge fabricating shops, forge shops, molding lofts, high-level outfitting docks. They rolled in their trench diggers and ran in their electricity, oxygen, water and acetylene lines. They laid the ways, installed big gantry and whirler cranes, turned many a stretch of barren, wind-swept coast into a maze of steel and concrete and cranes.

And when they had made the yards, some 70 of them, and had increased the number of ways to a total of 330, they tackled the job of building ships. This was a "natural," for contractors were used to assembling huge quantities of heavy materials, hiring and training crews of skilled and unskilled workers, coordinating operations for maximum speed, and improvising new methods when old ones were inadequate. To them, building a ship was simply a matter of building another kind of structure. So as they finished the yards they turned to ships.

Completely surrounded by scaffolding, a growing ship looks as though she is in a nest. Gantry cranes straddle her. The booms of whirler cranes swing back and forth over her, lifting and lowering vast quantities of steel. And the din is earsplitting—the screeching of cranes, the banging and screaming of steel on steel, the staccato clatter of riveters, the quick dull thuds from the forge shops, the hissing roar of welders. She becomes an inferno of sound.

It hardly seems possible that someday she'll be moving placidly on her belly over the horizon, her stack trailing distant wisps of smoke, her body swimming across oceans. Then all the fuss and noise and bustle will be a dream of men dragging her out of the earth, pushing her out of blast furnaces and rolling mills, pounding her aching ribs, plopping in her entrails and her great iron heart.

Of course she comes from the earth, from the ores and mills

and forge shops. She comes from hundreds of shops in dozens of states. All in all, more than 9,600 groups of items go into her. Some we make in small woodworking shops in the Northwest, some in tiny machine shops in the Middle West, some in the great sprawling mills of the industrial East. Here in the yard, they make her hull and put her together. Her pumps, engines, propellers, lifeboats, deck winches, etc., come from a hundred towns.

In building her they bend steel plates to the desired shapes. They do this with big presses while the plates are cold, then heat them with gas torches to relieve the stresses set up in bending. They prefabricate the bigger sections, the bulkheads, rudders, sections of deck and frames. Some of the big pieces weigh more than a dozen automobiles. One of the sections lifted and put in place is a portion of the shell sides; it is 28 feet wide and 60 feet long, as big as the floor area of two small homes.

Spreading the work out over a great many yards and plants and shops helped us to prevent the bottlenecks fought at the enormous Hog Island Yard during the First World War. Prefabrication of the larger and more complex parts also speeded production. But besides decentralization and prefabrication, welding, a new and American development in shipbuilding, enabled us to turn out ships faster than ever before. The conventional way was to punch holes in the plates and rivet them to a frame. It took time, was expensive, and required four men to each pneumatic hammer: one man to heat and toss rivets, one man to catch the hot rivets in a bucket, one to stick them in the hole and buck them, and one to operate the hammer. The rivets added weight—some ships had as many as 1,300,000 of them. The friction they caused slowed up the ship, and the holes in the plates tended to weaken her hull.

In some yards almost all seams were welded, some 54 miles

of seam were filled with molten metal on each ship. One yard averaged during a seven-day period some 19 miles of welded joint per 24 hours.

Another device to speed up production was the high-level outfitting dock which, with its ramps, brought the launched ship within reach of trucks, lowered the lift of materials from dock to ship by some 20 feet, eliminated time lost by workmen climbing up and down, and simplified utility connections.

As we pushed ahead, ship after ship splashed off the ways. The record runs: in March, 1941, we were building Liberty ships in an average of 228 days; June, 1942, 122 days; December, 1942, 55 days; and December, 1943, 39 days. In some yards Liberty freighters were launched in 4 days, 15 hours; completed in 7 days, 14 hours. Other yards turned out equally sensational records, one producing 15 ships in a single month, one ship every two days.

But the over-all figures tell the story more accurately. In 1941 we turned out about 1.1 million dead-weight tons; in 1942, 8 million; in 1943, 19.2 million. In other words, during 1942 and 1943 we produced about 24 times as much as we did in 1941. All in all, from the time the war started in 1939, we built, under the direction of the Maritime Commission, 5,558 ocean-going vessels of all kinds, approximately 54 million dead-weight tons, or about five times as much as we had at the beginning of the war. And more than 98 per cent of it was built after Pearl Harbor.

If you add up all the cold figures, big and little, you get thousands of ships and millions of tons of cargo; but you also get something far more important. You get the bone and muscle and sweat of men and women pushing a ring of bristling guns and bayonets ever tighter around our enemies; you get Eisenhower marching into Berlin, MacArthur riding into Tokyo.

28

Mother of Ships

THE cranes danced back and forth, their arms picking up steel plates and fabricated sections as easily as you'd lift a blueberry muffin. Men climbed over her like thousands of ants over the back of some huge beetle. Into her squat body and steel heart went some 60 miles of tubing, generators capable of supplying a city of 15,000 with electric power, propulsion machinery weighing 400 tons, more than 10,000 valves, 45 miles of piping. Indeed, to some, she seemed more like a floating city than a ship—a city made of steel and bristling with guns, a floating city packed with bombs and shells and rockets and planes. But to the men who sailed and loved her, she was much more than that; she was a lady—steel-plated, tough and glamorous.

She had her beginning when they first laid her massive keel, but her story and the stories of others like her go back much farther than that. Of course, her broad-backed body first appeared on the drawing board of some designer. But even then, she was little more than a theory frozen on paper—a dream that might materialize. Before the dream could feel the water caressing her body, and hear her guns barking, and her planes buzzing off her decks, she had to have a place to be born—a cradle to grow up in. And that cradle was her shipway.

They are not easy things to build, that is if you really do a good job. Take the case of the submerged shipway, for example.

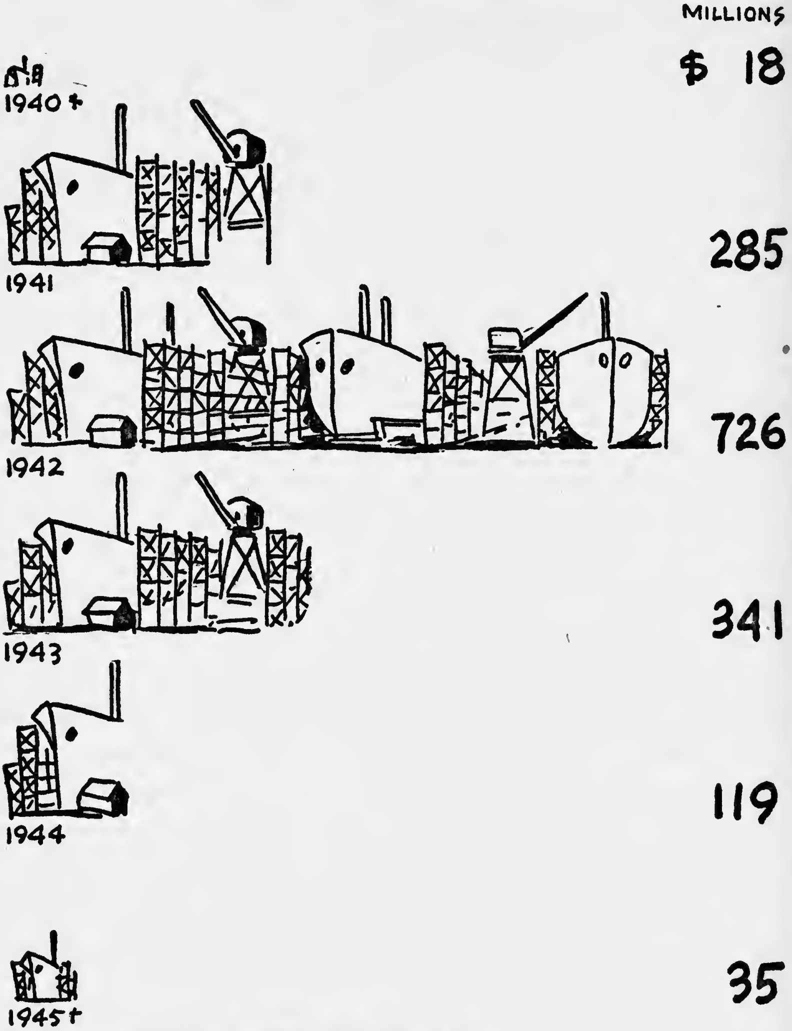
This kind is like a dry dock; you build your ship in a kind of big basement, some three stories deep, maybe 140 feet wide and 1,000 feet long. Then you open a few valves—water pours in and lifts her gently off the bottom. The steel gate at one end is floated out, and your ship is towed into the channel. Sounds simple, doesn't it? Yet building a submerged shipway can be one of the most difficult of all construction jobs. Here's the way they built two of them on the Atlantic Seaboard.

The idea was to build two basins out in the water along the shore. A good-sized area would be enclosed with dikes to keep the water out. As these were being built they'd dredge out the bottom of the basin and pour concrete on it. Then a big floating gate would be put in the end facing the stream; the water would be pumped out and finished concrete walls and floors would be built.

Contractors started by sinking long cylinders in the water and making borings to find out what kind of soil they had for their foundations. They found a thick layer of black, silty mud lying over a hard marl, which is a mixture of sand, lime and dirt—good hard stuff to build their dikes on. Then they hauled in their piles and floating cranes. The piles were long narrow sheets of thick steel with grooves on each edge, so that when you fitted them together and drove them down into the marl they'd keep out most of the water. They brought in their dredges, great, clumsy affairs plowing slowly through the water, then their big concrete mixers and pile drivers and underwater torches and other equipment.

Then they drove their piles to form a series of cells, each cell hooked with the next one and each about the size of a very large living room, that is, the floor area of such a room. The cells, or rings of piles, were about as deep as a three-story house is high. And the piles, of course, were much longer, seventy feet

We Built Facilities for Building and Repairing Ships



* LAST 6 MONTHS +FIRST 6 MONTHS

or more in length so that they could be driven deep into the marl.

From the air, at this stage, you'd see what looked like a series of big lily ponds hooked together in the form of a hollow rectangle. There would be water in each pond and water all around it. The whole undertaking would have appeared rather futile, just as though some damn fool were trying to make a chain of little lakes bordered with steel pile right in the river.

But soon the job began to shape up. They had to move fast, for the Japs were free to roam the Pacific pretty much at will. We could do little to stop them until we had more fighting ships. The Navy was hollering for destroyers, cruisers, battleships, aircraft carriers, and the hundreds of ships needed to serve them. In the Atlantic, German submarines were sinking ships faster than we could build them. Much hung on how fast we could build shipways and ships.

So they worked on their submerged shipways night and day, month in and month out, their long-armed cranes lifting steel piles up to one hundred feet long, their steam hammers hugging the tops of the piles, spurting steam out in little plumes, and banging and clanking all the way around the clock. Their whirler cranes with clamshell buckets danced dizzily in time with the eternal banging of steel on steel.

These whirler cranes, which have little houses built on them for their machinery and operators, revolve around and around. They are fascinating things to watch—their stubby chimneys pouring out black smoke, their fire boxes blinking at you through the night, their booms soaring over the water and swinging back and forth. You would see them sweeping over from a pile cell to the basin, the clamshells hanging on the end of their cables. Then, with jaws wide open and teeth shining, they plopped into the water and shot down to the bottom; their sharp teeth

buried into the marl; their jaws closed; with a series of short gasps from the engine they were jerked up to the surface and with water pouring out between their tightly clenched teeth they were swung over a cell, the jaws opened, and down poured big chunks of marl into the cell. This was repeated endlessly, back and forth in a kind of slow rhythm, the lights flickering on the big mouths and booms and little whirling houses, the engines puffing and gasping and sighing.

Gradually the cells were filled with marl, packed down good and hard, and you had a solid column of marl encased in steel pile. All the way around the rectangle this happened. Then, one day, a catastrophe loomed. It looked as though building those aircraft carriers might have to be postponed so far as this shipway was concerned. Routine checks showed that the tops of the cellular dikes were being pushed in, slanting some three inches toward the basin. If the dike was not made stronger in a hurry, the pressure of water outside the basin might destroy the whole thing, sweeping steel pilings away as though they were so many soda straws.

The reason for the impending tragedy was that the marl was not dry enough in the cells, and when it is not dry the stuff doesn't become hard, doesn't stick together. In this condition, it is weak. So they decided to do an amazing thing. They decided to squeeze the water out of the marl, force it to the surface or top of the cell and dump it overboard.

They lugged in steel pipes, 40 feet long and 12 inches in diameter. They stuck a steel cap on one end of each pipe, and they drove the pipes down into the marl. They drove a lot of them into the marl in each cell. This squeezed out the water. Then they filled their pipes with sand and packed it in tight. They connected air hoses with the tops of the pipes and sealed the tops with caps. As the air flowed against the top of each column of sand, they

started to pull out the pipe. As they pulled, their big crane straining, the bottom cap fell off. The pipe came out, but the air pressure kept the sand in the hole. When they finished the job, they had plugged the marl with hundreds of columns of sand forty feet deep. Water from the marl ran into these sand plugs; but that was not the end—they had yet to get the water out. So in the center of each cell, inside some of the pipe to take the sand, they put another pipe, one that was much smaller, about four inches in diameter. Then they packed sand inside the big pipe and around the little one, which was slotted. Now they yanked out the big pipe, but the little one stayed in with the sand all around it. Water seeped through the sand, dripped through the slots in the pipe and was pumped out. Soon the marl was dry and hard, the dike strong.

As they built their cells around the rectangle, they also dredged the enclosure, their clamshells biting out mouthfuls of black, muddy silt from the bottom, eating into the hard underlying marl, until the area was deep enough and there was a good, sound bottom on which to pour concrete. They poured this under water, their submarine buckets swinging back and forth from the mixer to the bottom of the water, dumping load after load on the marl until there was a floor about six feet thick (not six inches, but six feet). This sealed off the water and stopped it from pouring in from underneath. But as the water exerted a tremendous pressure, the bottom being much lower than the water in the river, they played safe and stuck a series of pipes through the concrete. The tops of these pipes were connected with horizontal pipes that drained off any water coming through. If they hadn't done this, the water might have forced up their concrete slab, cracking it and destroying the whole shipway.

In building the entrance to the shipway, they first erected a cofferdam by driving grooved sheetpiling close together in the

form of a long, narrow rectangle. Then they pumped out the water, and got down into their dam to work building a concrete seat for their floating gate. The gate is a huge floating affair made out of steel. It floats on one edge, that is, it is perpendicular to the surface of the water and, of course, is mostly submerged, like some crazy kind of boat. When the gate is in place, water pressure from outside holds it tightly against the gate seat and presses its big strips of rubber tightly against the concrete of the shipway, thus sealing out all water. When a ship is finished, water is let in through valves and the gate can be floated away.

The shipway was now ready for the finishing touches. They pumped out the water. They poured a new concrete floor some two feet thick over the rough floor; they capped their cells with concrete and poured their crane walls around the side. Tracks were laid on top of the cells and big cranes were installed. The shipway was ready for action.

This submerged shipway is a kind of super affair, quite different from the usual ones built on land, or partly on land and partly in water. In this one, ships can be built horizontally, instead of on a slant as they usually are built to permit launching. It can also serve as a dry dock, and has certain other advantages.

In those two submerged shipways were born the *Franklin*, the *Intrepid*, the *Randolph*, and that colossus, the 45,000-ton *Midway*—all aircraft carriers and all, lethal chunks of steel packed with planes, bombs and shells. Perhaps the *Intrepid* is the most interesting of the three smaller carriers, all of the *Essex* class. This doughty lady, bristling with guns, homely and fat, her big landing deck spread out over her like a huge mortarboard hat, was hit oftener than any other carrier in the Navy.

But she fought back. They just couldn't sink her. They tor-

pedoed her and blew out her steering mechanism and jammed her rudder. But with the help of sails mounted on her forecastle her crew managed to get her back home. She was hit again and again. Off Luzon a Jap kamikaze attack got her. Another time a Jap Zeke rocketed into her flight deck, its bomb exploding in the pilots' ready room. While the crew fought the resulting fire, another suicide plane crashed into her and tore two great holes in her deck. Months later, other suicide planes crashed into the old lady, shaking her from stem to stern, tearing through her hangar deck. The impact of one plane was so great that the exact imprint of its wings was smashed into the flight deck.

During those ordeals she fought back with all she had, her guns throwing up a ring of steel about her, her great engines throbbing wildly, her course a dizzy zigzag. And when the bombs struck, her whole body trembled and shook. But her guns kept lashing out and her crew kept fighting and she always lived to fight again. Four times she limped home, painfully, slowly. And four times she set out again.

And each time she fought courageously. She threw her planes at the Carolines, the Philippines, the Marianas, and the Jap home islands. She was at Iwo Jima and Okinawa. Her planes roared off her deck angrily, making kill after kill. They blasted to the bottom some 80 enemy ships, including an aircraft carrier. They closed in over the Japanese superbattleship, the *Yamoto,* like a swarm of angry hornets, and helped send her to the bottom. Her planes and her guns brought down 650 enemy planes. Her fliers probably sank 30 other enemy vessels and damaged an additional 279 ships of the Japanese Navy.

She fought like the hard, tough old lady she was. And when she came sailing home after it was all over, she is to be excused

for feeling just a little perky and a little proud. And her crew can be pardoned for strutting about her deck as though she were the queen of all carriers.

Along with her in some of her operations were hundreds of others—destroyers, cruisers, battleships, and other carriers; and not so very far off were tankers and supply ships of all types. There were Liberty ships, plump and low in the water, almost bursting with food and clothing and weapons. There were the LST's, those awkward ships with big mouths. There were fat army transports packed with soldiers. In short, slowly disappearing over the horizons of the world was the whole armed might of the country.

Here was the tangible result, the end product, of building our sprawling war plants, huge cantonments, and hundreds of shipways—building them well, efficiently, and faster than it was ever believed possible to build.

29

Ships That Lift Battleships

OUR Navy had a secret, a trick that played havoc with the enemy in many a naval battle. It was not one of those glamorous, breath-taking secrets like the atomic bomb or the superfort or the ship-borne rocket. It was, in fact, a rather humdrum kind of mechanism, but one which performed miracles and when the going was tough saved the day.

First, the Japs would batter one of our ships until she looked done for, fit for the bottom, or at least requiring a long trip home for repairs. She'd be out of action, they'd figure, at least three months, maybe four—time enough for them to throw plenty of lethal punches. Then, maybe three weeks later, they'd see her again, as powerful and fast and hard-hitting as ever—like a ghost ship suddenly come to life and tearing into them with all guns blazing.

This happened time and time again. They couldn't understand it. They felt certain we had no dry docks west of Pearl Harbor capable of handling capital ships, and that even at Pearl Harbor repair facilities for carriers and battleships were limited. This, they reasoned, could only mean a trip back to the West Coast and if the yards there couldn't take her, she'd have to go all the way around to yards on the Atlantic Seaboard.

The answer, of course, was our floating dry docks—a kind of hospital ship built especially for our wounded ladies. They were built in sections, sometimes as many as ten sections, each

a ship in its own right. And what a peculiar craft it is. Her hull is broad and short, her nose stubby, her stern clumsy. On her deck are two enormous steel boxes with the boom of an electric crane jutting over one of them. Inside the boxes, which are flat, are quarters for officers, plus lots of space into which water can be pumped. In her hull are quarters for the crew, a galley, pumps, machinery, diesel-driven generators, boilers, and more space for water.

Ten of these fat old ladies are towed across the ocean to a remote and secluded atoll. They are lined up. Hydraulic jacks swing the two steel boxes to an upright position and they are fastened down to the deck, one across the forward deck and one across the after deck. Now they look like two thick walls of steel riding an old scow.

Soon, they bring two of the sections side by side and weld the ends of the walls together. Other sections are brought together and welded, and before you know it you have a very strange appearing craft, indeed, its hull made up of the ten hulls of its sections, and its deck lined with two long steel sides. On these walls are electric cranes that run on tracks. The whole thing is anchored down and it is ready to start saving ships.

She may not be the Dorothy Lamour of the Navy, but she is big and powerful. Her over-all length is nine hundred and thirty feet and there is a working space of one hundred and fifty feet between her sidewalls.

She is so powerful that she can lift a hundred thousand tons right out of the water—much more than the weight of our biggest capital ships. Once she lifted two light cruisers at the same time, and once repaired 11 light craft at a single crack. After she lifts them out of the water and repairs their wounds, she lets them down gently. They move slowly out of her big steel arms, and are on their way back to hammer the Japs.

All this takes very little time, a matter of hours, not months. When a ship comes limping up to her, they let water run into her sidewalls and the hulls of her sections. All of her, except the top part of her sidewalls, sinks under water. The wounded battleship runs in between her sidewalls. They pump the water out. She rises and, of course, the damaged vessel rises with her. Then her cranes get busy, her machine shops hum, and her crew tears into the job of getting that ship back into action.

The Navy calls these docks ABSD's, Advanced Base Sectional Docks. They are an entirely new type, no other navy has anything like them. During one eight-month period they nursed back to health and action, one hundred and seventy-six ships.

One of their earlier jobs was to repair three battleships in record time. Shortly afterwards, those battleships gave a good account of themselves in the battle for Leyte Gulf. Without the ABSD's, they would not have taken part in that critical battle; they'd have been on their way back to the States for repairs.

Besides the ABSD's, the Navy designed and ordered other types of floating dry docks. There are the Yard Floating Docks, or YFD's, which are built in three sections and are big enough to lift most merchant ships and fighting ships up to the size of cruisers. And there are the Auxiliary Repair Docks, big enough to handle destroyers, LST's and smaller craft. These docks look like ships and are easily towed. They will even carry a ship while being towed.

Building floating dry docks was the job of twenty-three construction firms. Docks of that type were relatively new when the program was first launched in 1940. At that time we had only three floating docks, one in the Philippines, one in New Orleans, and one on the Pacific Coast, and they were of a completely different type. Building them in record time when our fleet almost depended for its very existence on them, building

them according to new designs, was a task demanding all the ingenuity and skill and determination those firms were able to muster. But they did it.

In addition to floating dry docks, we built graving docks, which are fixed dry docks. They do the same work as the floating docks but usually are bigger, some of them being 1,100 feet long. These docks along with floating ones can, if strategically located, have the effect of doubling the size of the fleet. For example, one big graving dock at Pearl Harbor, completed by contractors in record time, just a week or two before December 7, 1941, was partly responsible for the rapid recovery of our Navy.

These graving docks, as was mentioned in the section on submerged shipways, which are much the same, are extremely difficult things to build. Not many years ago, many a contractor went broke trying to build them; often the construction job required from five to eight years and most of them were built only after terrific struggles and long delays.

During the war a great many graving docks were built, most of them of gigantic size and in a fraction of the time formerly required. Many were built by conventional methods, but in some instances where unstable foundation conditions were found, a new and radically different method was used. This type of construction, developed by the Navy, made it possible to build most of the dock body under water. The bottom of the dock and sidewalls are built by the Tremie method, which consists of pouring a fairly dry concrete mix through an enclosed chute into forms under water.

Not only did we tackle such difficult construction jobs but we completed our dry-dock program in remarkably little time and on a scale that eventually outstripped the docking facilities of the entire world up to 1938.

30

You're in the Navy Now

THE Navy needed men who could move the jungle out from under Japs, tear off the tops of mountains, and turn remote Pacific atolls into modern cities. It would also be nice, the Navy thought, if the same men could turn a pile of junk into a washing machine or a power shovel. And then, of course, the Navy felt it would be best if they were the kind of men who could work a week at a time without sleeping, shoot Japs with one hand while working with the other, and whip up just about anything they happened to need when they needed it.

So they organized the Seabees. And you can't talk about the war without talking about them. They are the fabulous characters, the Paul Bunyans. Their footprints are on every beach.

These landlubbers strode from island to island in steps a thousand miles long, turned jungles into cities, carved airfields out of solid rock. Not only did they do those things, but they often did them under fire. At Guadalcanal they put Henderson Field back in shape and kept it going in spite of 140 bombing attacks, lack of equipment, Jap snipers, and jungle heat. When the Japs came over they'd dive for the nearest foxhole. If they were working out in the middle of the field and didn't have time to get to shelter, well, they just kept on working.

If you crave something a little more bloody, not merely working while bombs blasted holes about you and Jap machine guns spat up the dirt beside you, there is the story of the Seabee on Mono in the Treasury Islands. His name was Aurelio Tas-

sone, a slightly built Seabee who was a dozer man attached to a New Zealand outfit. As they approached the beaches, he and the other dozer men nervously smoked and waited, tense and all tight inside. Their LST was getting the works. They could hear shrapnel slapping the ship. Suddenly, there was a direct hit on the topside. It cleaned out a gun crew. Below, on the tank deck, they heard the concussion.

Then the ship scrunched on the beach. The bow doors swung open and they saw dead Americans and New Zealanders floating back and forth in the surf. It was their first view of combat and it was like something out of a nightmare. But they got their bulldozers on the beach as fast as they could. They started gouging out gun emplacements, the dozers grunting and rocking, the sand flying in rippling streams off the blades. All the time shells were raining down about them.

Tassone, like the others, was too busy to see much. He only knew the shelling was raising hell with the landing operations and the sooner he did his job, the sooner troops would push the Japs back. Then Lieutenant Charles Turnbull, a young Civil Engineer Corps officer, hollered at him. "Get that damn gun. Smash it!" He pointed at a pillbox that was mowing down our men, picking off boats.

Tassone saw that about two feet of the pillbox was above ground and that it was lined with coconut logs. For a split second he hesitated. Then the big dozer growled clumsily forward, crouching, hugging the ground like some powerful beast. Tassone drove faster. It gathered momentum. He kept the huge blade high in the air, in front of him. He heard bullets pinging against the blade and saw Lieutenant Turnbull striding along behind him with a Tommy gun, attempting, he guessed, to protect his rear. He didn't have time to think. But this was it—one man on a bulldozer, one Jap pillbox.

A few feet from the pillbox, he let the huge blade fall. The motor coughed and sputtered. For a moment, he thought it was going to stall. The dozer rumbled ahead. There was a splintering crash. Logs flew into the air. The dozer smashed on through. Everything was buried. He wheeled around and started to come back at it, when Lieutenant Turnbull yelled at him to lay off before he exploded any live ammunition.

Digging away the wreckage, they found twelve dead Japs, plenty of small arms, and a twin-mount 37mm. gun. Later, when Tassone was awarded the Silver Star, he said, "I had the bulldozer blade for protection. The Lieutenant had nothing but plain guts."

There are other examples. Almost every island has its quota. But the big thing is the way Seabees threw together construction jobs of every conceivable sort. They did them in a matter of hours and days.

The reason they could be done so fast, of course, was the know-how the Seabees brought to their task. This plus heavy construction equipment and plenty of guts did the job. In civilian life they were construction workers. They were carpenters, electricians, crane-men, welders, bulldozer and shovel operators, steel workers, piledrivers. Their officers were contractors and construction foremen, architects and engineers. All in all, 59 different trades were represented in each construction battalion. There were about 1,080 men in a battalion.

Besides the regular construction battalions there were other Seabee units who did various specialized jobs, such as unloading ships, clearing harbors, repairing construction equipment, building depots at advance bases, constructing piers, quay walls, and water-front facilities. Also there were underwater demolition teams, who waded in before the landings and searched the shallow water and beaches for mines, then destroyed them right

under the noses of the enemy. Other teams hooked up the pontoon causeways and piers over which heavy combat and construction equipment rolled to the beaches.

The Seabees or Construction Battalions were born out of the ruins of Pearl Harbor and Wake. We had to build hundreds of airfields, ammunition depots, hospitals and scores of other facilities. And we had to build them fast, often under Jap air attacks, sniper fire, and the pounding of Jap artillery. Civilian construction workers at Pearl, Midway, Wake, Guam, and elsewhere, had done a brave and outstanding job under the toughest conditions, facing danger unflinchingly; still we needed men who could both build and fight. It was essential for us to have construction workers trained in military discipline, familiar with combat duties, and able to protect themselves while working under enemy fire.

To some extent the men in the Seabees were unique. They were older than the men in the General Service of the Navy. Most of them were married and had families. Practically all of the skilled men were members of trade unions. Most of them could have avoided military service because of their age, number of dependents, and their essentiality to the civilian war program. But they wanted to get this war over with, and they volunteered by the thousands. They left their bulldozers and power shovels and cranes. They climbed down from their steel bridges, and high tension towers. They left the roads and railroads they had strung across the continent, the endless streets of homes they had built, the factories and powder plants, the city-like camps they had pushed up out of the earth. They left construction projects that had helped turn the country from a war weakling into a hard-hitting adversary.

When the Japs zoomed down on Pearl Harbor and blasted what they had built, when they seemed to threaten the cities on

the Pacific Coast, they felt as though a Jap had spat in their faces. They took it as a personal affront. They had built the stuff, and now they'd defend it. If construction was such a vital link in the winning of the war, then war was their meat.

What they did and how they did it is a heart-warming and exciting story. It's a story about the little-known men whose courage and know-how helped make possible our strides across the Pacific. For if it had not been for these men with their bulldozers and power shovels, our superforts could not have struck their deadly blows, our Navy could not have crushed the Jap fleet, and our troops could not have hopped from island to island.

It's a big story. They fought and built their way across the Pacific; helped make those man-made harbors off the Normandy coast; worked with Army Engineers in the Pacific and in bringing many a European port back to life; sweated it out at the Rhine River crossing; and helped put hundreds of thousands of marines and soldiers on the beaches of the world. In Sicily, for example, their pontoons, those magic steel boxes, fooled the Germans and helped to make that landing operation successful.

31

A Magic Steel Box

When German aviators swooped low over the coast of Sicily on that fatal July morning, they could hardly believe their eyes. Below them were hundreds of ships, many of them pouring out their cargoes of trucks, tanks, artillery and troops onto beaches considered invasion proof by the German general staff. So sure were the Germans that shallow water would prevent landing operations, that they concentrated their defense along deeper sections of the beach.

The German aviators looked again, staring down at the ships and the narrow thread-like roads over which supplies were rolling from ship to shore. They came down and saw that the roads were peculiar contraptions made up of hundreds of steel boxes, floating and plunging in the surf. Then they set to work on them, bombing and strafing the slender lifelines. All their fury was concentrated on these narrow steel ribbons unloading ship after ship. But they failed to stop us and 10,000 vehicles rode over the ribbons to shore.

The story of that landing and hundreds more like it goes back to a tobacco and candy stand in the Navy Department Building in Washington. For weeks the concessionaire had been saving cigar boxes for Captain John N. Laycock. Two or three times a week the Captain would drop by the stand and get his cigar boxes, carrying them back to his cubbyhole of an office where he'd string them together, experiment on various ways of hooking them up and of bracing them.

Finally, one day, he had it. He placed a chain of the boxes on his desk, each end resting on a pile of books. He pressed down in the middle, the string of boxes remained rigid. He pressed harder and found his cigar-box bridge strong. For a second he hardly dared to believe he had succeeded, for success had come hard—night after night of designing, calculating, experimenting. Success meant that our troops could pour from ship to shore on almost any coast in a matter of minutes; that medium tanks, trucks, bulldozers, and all the other heavy paraphernalia of war could be unloaded faster than ever before.

On the basis of his experiments with the cigar boxes and tests with chains of steel boxes along secluded coasts, the Navy decided to go all out on its new pontoon unit. The boxes were made of steel, 5′ x 5′ x 7′. Seabee crews were trained to bolt them together, to launch them from rapidly moving ships, and to fasten the units together in various combinations. When strung end to end they provided floating causeways from ship to shore; hooked up another way they were barges, or floating bases for cranes, seaplane ramps, docks, finger piers. When arranged in still another way with uprights to stabilize them, they served as floating dry docks capable of lifting a thousand tons out of the water. A combination of pontoons was filled with water and sunk, a ship nestled on top of it. Then compressed air forced the water out, the pontoons rose on uprights, lifting the boat out of water, all ready for repairs.

When a landing operation called for an exceptionally long string of boxes, two causeways were used, one lashed on each side of an LST. As the ship moved to the beach, the cables were cut and the pontoons splashed into the water; the boat would ground, the two pontoon strings would sail on ahead, driven by their own momentum. Then one chain of pontoons was pulled back with a cable and fastened to the ship; the other pontoon

chain, still moving ahead, would bump into the beach. Then Seabees lashed the two strings of pontoons together. That's about all there was to it.

But the operation was not so simple as it sounds, especially when the pontoons were plunging wildly in a heavy surf, when enemy planes swooped low, their machine guns spitting at the men riding the long, cumbersome steel causeways, and when all possible fire power was concentrated on them. The hazards involved were expressed by a young paratrooper at Salerno who had been watching the Seabees at work on pontoon causeways under severe bombing and strafing attacks. For several minutes he stared at the men fastening the steel boxes together. Then he turned to a Seabee standing beside him and said, "And I always thought us paratroopers were the damnedest fools in this war."

The adaptability of the steel-box pontoon unit was demonstrated time and time again. Hooked together and powered with heavy outboard motors, they made Rhino ferries. Another combination turned them into tugs.

One of the little-known stories about them was brought to light when the Navy announced their use in helping to unload PT boats from the deck of a freighter off New Caledonia. The PT boats had been loaded on the freighter and rushed to the Pacific for use at Guadalcanal. Then suddenly it was discovered there were no cranes at our Pacific bases capable of lifting them off the decks. By this time the freighter was far at sea. Day and night men worked at the Navy Department designing a huge pontoon barge from which an enormous crane could operate. Blueprints for the crane were rushed to the shops where it was built in breath-taking time. Pontoons, crane, and slings were loaded on a fast freighter and sent scurrying across the Pacific. When the PT boats arrived off New Caledonia, the enormous

crane, mounted on the pontoon barge, was ready. It plowed ponderously through the water and stood by. Its awkward, high-hipped boom picked the PT boats up as though they were toys, lifted them over the side and set them down on the water as gently as you'd put a baby in bed.

At Normandy, Rhino ferries, self-propelled barges made up of pontoons, played an important part in the success of the invasion. Seabees ran these ferries from ship to shore. Day and night the great barges plowed back and forth, loaded with tanks and trucks and ammunition and other supplies. Other Seabees towed in strings of pontoons and sunk them at high tide, building a steel roadway from ships to shore, usable at any stage of the tide. During the first week of the Normandy invasion, over 85 per cent of our vehicles were landed on one of the beaches by means of pontoons. And this was done during the critical time when every pound of equipment counted and when a shortage of supplies might well have cost us a toe hold on the continent.

The Seabees and their magic steel boxes brought the sinews of war ashore at a hundred other landings. They were working in the landings in the Marianas, the Palaus, the Philippines, and at Iwo Jima. They were at Okinawa and other islands strung throughout the Pacific.

In the early phases of the Ryukyus campaign, one Seabee pontoon battalion launched and put together causeways that unloaded more than 115,000 tons of high priority "hot" cargo and over 65,000 troops. The same battalion operated warping tugs, refloating some 300 stranded landing craft, including an LST. It was that way all over—even in the Aleutians where Seabees fought tundra and cold, fog and mud, and in their spare time killed Japs.

32

We Bend Back a Dagger

An important part of Jap strategy was to take the Aleutians. Having done that, they would bomb our West Coast cities, raid our shipping, and hound our Navy into a defensive war. It was a good plan. But somehow it didn't work so well. And one reason it didn't work was that the Seabees and the Army Engineers could build faster than the Japs, often doing in a single day what the Japs required months of backbreaking labor to accomplish.

We tore into the Aleutians like a Texas cyclone, knocking airfields out of frozen tundra six and eight feet deep, building barracks in the teeth of screaming gales, pushing mountains of dirt into the sea, cutting roads through solid rock, all the time fighting cold and fog and rain and mud and snow, not to mention the Japs.

Some of our feats the Japs have lived to regret, many of them made construction history. On Adak, for instance, you can see one of the most amazing airports in the world. This island, bleak and barren, is well out on the Aleutian chain. We had come a long way, fighting, building, stepping from island to island. We had whipped Dutch Harbor into a powerful base, and we had landed on Uznak where speed in making airstrips hit the jackpot. For, a few days after we laid pierced-plank mat on the tundra, the Japs attacked Dutch Harbor. Our planes were ready and the Japs were taken by surprise, seemingly thinking we had nothing west of Dutch Harbor.

We hit the beaches of Adak the last part of August, 1942,

and within a few hours were turning a tidal swamp into an airport. At high tide the swamp was flooded with water five feet deep, but it had a good sandy bottom. The eastern edge of the swamp was studded with high sand dunes, the western edge fringed with foothills. A stream ran through the center of the swamp. Our bulldozers rumbled up and moved the stream over to the foothills, then they heaved up a dike at the sea entrance of the swamp. This kept the ocean out at high tide. Drainage from the stream was handled by simply breaking down the dike with a bulldozer at low tide and letting the backed-up stream water flow out, then pushing more dirt in the gap just before the tide started to rise.

Bulldozers and scrapers attacked the sand dunes, biting into them, pushing mountains of sand down into the swamp, filling up the original creek bed, and cutting drainage ditches on each side of the swamp. Steel mat was laid on top of the sand. Four days after we arrived on the beaches bombers could take off from a 3,000-foot strip. Later, we made the field bigger, put in a wooden tide gate, installed pumps to help keep the field dry and built hardstands and taxiways.

Five months later, our bulldozers growled onto the beaches of Auchitka, heavy construction equipment lumbered up the shore, and we were doing a repeat performance. Here we turned another tide-engulfed valley into an airfield by filling it with sand, first raising the end near the sea by pushing in enough sand to keep out the water.

Our next jump was to Attu, springboard for the final leap. We were smack up against the Japs' back door, just 740 miles from the naval base at Paramushiro and 1,800 miles from Tokyo. Our construction men poured out on the beaches in a fog so thick that they could not see their equipment. They helped establish the beach head, kept supply lines working, fought off

a thousand counterattacking Japs, dozed out airstrips, and took time out to build miles of road through the tundra.

All the way out the Aleutian chain it was pretty much the same story—another island, more airfields and roads, warehouses and barracks. All the way they fought mountainous terrain, ever-present tundra, numbing cold and fog and rain. On one island they drained the water out of three lakes, scooped out the soft muck, smoothed out the lake bottom, and made an airfield. On another bleak, raw island, drowned in fog and snow, they made an airstrip by building a fill as high as a five-story house and a half mile long. And on another spot, they carved out a long airstrip, half on one side of a valley, half on the other side, and hooked them together by swinging a bridge over a small river separating the two strips.

Then there was the job of keeping our supplies moving in. On some islands we built piers—big, heavy ones, capable of handling thousands of tons of food and ammunition and construction equipment. Driving the piles for these piers and wharves was not easy, for often the harbor bottoms are solid rock. In one harbor we filled the bottom with quarried rock to give the piles something to hold on to.

If we couldn't find a natural harbor, we built our own, throwing out jetties and breakwaters, sometimes dozing them out from shore. They had to be strong, for when Aleutian storms lash down over the islands they sweep just about everything before them, knocking 10,500-ton Liberty ships about as though they were cardboard models.

To get supplies back from the piers, we built hundreds of miles of roads in some of the most formidable terrain in the world. Sometimes we snaked them over tundra, mashing down sand and gravel to keep our equipment from sinking into the wet mass of mud and grass. If the tundra was only a few feet

deep, we sliced it away, and cut roads out of the hardpan underneath, cutting drainage ditches along the sides to keep the roads from becoming rivers and seas of mud.

It was a long battle against whipping sand and bitter cold and howling storms, fought by men working in the all-engulfing fog and the long nights. The northern road to Tokyo was finished, a saber pointing at Japan, ready to strike.

Far to the south, in the jungles of the Solomons, Seabees were lifting islands out of the mud, fighting dive-bombing mosquitoes, and digging the thick, matted greenery of the tropics from under Japs—but this is another story.

33

You Are on Guadalcanal

Day after day the Jap planes droned over Henderson Field. In one 18-day period in November, 1942, they came over 140 times, averaging about eight bombing attacks a day. When the Japs looked down at the narrow gash of white in the green jungle, their slant eyes stared at our men running for cover, trucks dashing madly back into the jungle, bulldozers lumbering for shelter. But always when they came back, buzzing angrily and expecting to find a pockmarked field cut to pieces, they saw instead a smooth strip in full operation. There was something uncanny about it. A kind of white man's magic that automatically sealed over the craters.

If they'd seen how the Seabees filled those craters, they would have realized that there is a certain magic in plenty of muscle and sweat, in bare hands that filled hole after hole, in tired and aching bodies that continued to push trucks out of jungle mud.

Before the Jap planes disappeared, the Seabees were jumping out of their foxholes by the side of the field, racing across it to the craters. Trucks ready-loaded with just the right amounts of dirt were speeding across the strip. They'd scream to a stop beside a crater, back up, and let the dirt roar down, filling up craters almost as fast as the Japs made them. When there wasn't enough equipment and the going got tough, they'd pitch in with their bare hands.

At first they used patched-up Jap machines, for in the landing they'd lost almost all their construction equipment. That blow

alone nearly cost us Guadalcanal, the toe hold that probably saved Australia and provided us with the springboard on up a long chain of islands to the Philippines and Okinawa. But they used what equipment they had. They improvised, and sweated it out. And when Henderson Field was finished, we had a greatly enlarged field, covered with 18 inches of crushed coral and topped with pierced steel planking. Our planes were taking off for Munda and we were on our way up the bloody road to Tokyo.

The Japs on Guadalcanal were bad enough, but the mosquitoes were worse. These miniature dive bombers wrought havoc among us, causing far more casualties than the Japs. Of all our enemies, malaria was the most dangerous and the ugliest, and the fight against it was a fight for survival in the jungle with its steaming heat and dank swamps.

Here was a construction job tough enough to challenge any outfit: a dirty, dangerous, back-breaking, thankless job. Just the kind for Seabees. They tore off the mosquito netting about their heads, they tossed away their gloves, they stripped to the waist, and they waded into the jungle. It was full-steam-ahead and to-hell-with-the-mosquitoes.

Bulldozers growled through the undergrowth, pushing ribbons of dirt before them, knocking down trees, filling low places, digging wide ditches. Clamshells, dropping their great steel jaws down into jungle ooze, bit out huge chunks of dripping mud, clanking as they lifted and plopped the stuff into trucks. Winches, mounted on Bren weapon-carriers borrowed from the New Zealanders, strained and screeched as the heavy cables grew taut, tugging at stumps and roots. They drained the swamps and filled in the pits and smoothed out the ruts. Then they fought the mosquitoes with sprayers.

When they were through, the Army's bug experts were amazed at Seabee thoroughness and speed. The jungle's deadli-

est insect had bit the mud. In seven months the malaria casualty rate fell to less than one-fourth of one per cent. And by the end of 1943, our camps were just about free of the disease.

By this time, Guadalcanal was fast becoming one of the strongest, hardest-hitting bases in the Pacific. Henderson Field now had two fighter strips, and bomber strips had been carved out at Carney and Koli. A complete water-supply system was installed, facilities to load and store fuel were put in, and badly needed supplies from the States were pouring onto the island. We had dozed out of the jungle some 200 miles of all-weather roads, some of them four-lane highways. And we were throwing bridges of teakwood, mahogany, and other jungle woods across streams and rivers whose waters sometimes rose as much as 12 feet in a single hour. One bridge used enough mahogany to make thousands of living-room suites. In this country the wood would be worth about $250,000.

The job was never-ending. We built "T"-type piers, the legs of the "T's" some 500 feet long, and the "T" crosspieces or fronts 400 feet in length. We built a tanker anchorage, facilities for pouring 200 gallons of drilled-well water a minute into our thirsty ships, and we took over the Jap communication system. We seized this system so suddenly and with such fury that Jap breakfasts were still warm when the Marines moved in. But the Jap equipment was shoddy stuff and we had to improve on it, erecting an antenna that soared up into the sky some 150 feet, that is, as high as a fifteen-story building. The Seabees did this by splicing two enormous mahogany logs together with steel bands. Each log was 90 feet long and weighed many tons, but we put up six of the towers in spite of Jap bombing attacks and our own makeshift equipment.

And we built great storage depots from which supplies flowed on up to the other islands. We built small cities, complete with

water, lighting and sewage-disposal systems. The island became a staging area for the sledge-hammer blows soon to follow.

On Guadalcanal, as on many other islands, Seabee ingenuity saved many a construction job. They made nails out of iron rods from steel mats, fabricated shears to cut galvanized iron and steel plate, built a "low-boy" trailer for hauling heavy cranes and bulldozers, improvised magnetic road sweepers and used them for picking up stray metal. Their Guadalcanal model oven, made from pontoon cells lined with firebrick from native copra ovens, turned out piping hot biscuits, buns, and crisp golden-brown loaves of bread. Even the early water-heating system, the incinerators, and the laundry, were born out of Seabee construction know-how.

It took the Seabees about a year to lift the island out of the mud and to turn a once festering, swampy, malaria-ridden speck on your map into a bit of America with traffic cops, chocolate nut sundaes, tennis courts, and steam laundries. About a year after they were crouching in foxholes beside Henderson Field, Seabees had made it possible for you to sip a coke tinkling with ice, go to a lovely little chapel made of contrasting woods, go to the theater and see the latest pictures, and even ride on the Guadalcanal, Bougainville and Tokyo Railroad which connects the docks and the warehouses. Such touches of Americana, of course, came after the long, hard struggle against jungle and the Japs.

But the island road up from Guadalcanal and the south to the Jap citadel, and the northern road through the Aleutians, were not enough. We were building another across the central Pacific, through the Gilbert, Marshall, Mariana, Bonin, and Ryukyu Islands. In June, 1944, we hit the Marianas, which are 1,500 miles from Tokyo and more than 2,000 miles northwest of Guadalcanal. In this group are Guam, Saipan, and Tinian,

which soon were to feel sledge-hammer blows and to see construction on a scale never dreamed of in the past. Here, the construction lessons learned on many a job back home paid big dividends.

34

The Tinian Miracle

On the morning of December 21, 1944, three huge planes circled a tiny island less than 1,500 miles from Tokyo. Soaring through the blue Pacific sky, their wings glinting in the sun, they looked like enormous birds searching for a home. The planes swooped low and kissed the first completed runway big enough to land B-29's on Tinian.

Later, flocks of the great planes hovered over the island every day. More and more came, like wild geese landing on some pond. And as their numbers mounted, we turned the island into a gigantic nest from which would fly superforts, carrying death and destruction to the very heart of the Jap citadel, burning his cities, smashing his factories, blasting his fleet, and striking terror into his sun-worshiping soul.

Everyone knows about the devastation these man-made birds of prey rained down on the Jap homeland. Not so generally known is the story of the construction work that lifted such raids from the realm of wishful thinking. Yet, back of the destruction of Jap cities, back of every superfort raid, were the earth-bound bulldozer, the sharp-toothed dragline, and the clumsy, waddling carryall.

On Tinian the construction job was gargantuan. One of those colossal affairs, like building Boulder Dam, Rockefeller Center, and an entire city all at the same time. The figures are astronomical and the sweat is salty Seabee sweat.

When we landed on the morning of July 24, the Jap airstrip

at Ushi Point was as full of holes as a piece of Swiss cheese. It was the first field we captured and now, because a storm prevented the removal of casualties by sea, we needed it to facilitate flying our wounded back to hospitals. The Seabees went to work on the strip, using only eight trucks, nine bulldozers and two tandem rollers, plus some hastily repaired Jap equipment. In less than 24 hours after the orders came through from Saipan, the first plane took off. All in all, 300 wounded men were flown out by C-47 planes that first day. Day after day the lumbering planes came down, squatted on the field, received the wounded, and disappeared in the sky.

Airfield followed airfield. The entire island, some 48 square miles of flat plateau and gently rolling hills, was turned into a huge construction job. We sliced off the tops of hills, and dug coral pits so deep that they looked almost like canyons. The dull booms of blasting charges reverberated day and night, bulldozers rocked and bucked against cliffs of coral, power shovels sank their sharp teeth into the dirt, groaning as they lifted their loads, tossed them into waiting trucks. All the way around the clock they worked, and at night it seemed as though you were in another world, a kind of ghost world of flickering lights, grotesque steel monsters, and sweating, tired men. An unholy symphony of sounds filled the night air: the growling and rumbling of loaded trucks, the dull, monotonous booms from the coral pits, the panting and sputtering of bulldozers, the screeching of cranes, the rattling and clanking of draglines, the roar of dirt falling into trucks, the sharp, staccato barking of air drills.

It was the kind of symphony that built Grand Coulee and Boulder, laid the endless steel rails across the continent, bored tunnels through mountains of granite, stretched ribbons of concrete across prairies, spun the steel high above our cities.

Here in the Pacific it was an incongruous, a foreign thing. And its objective was death.

The figures on this hornets' nest, this spawning ground of destruction, almost seem to reach to the moon and back. On the island is the world's largest airfield, more than double the size of Idlewild, the Long Island dream which a prominent magazine once declared would be the biggest airport in the world in 1947. Theoretically, planes will be able to land and take off at Idlewild at the rate of six every minute. On the same basis, the Tinian airfield can handle eight planes a minute, 480 an hour.

In cutting out this airfield, we drilled as many as 12,000 holes for that many explosive charges for a single blast. We dug and lugged around almost 12 million cubic yards of coral, equal in volume to three Boulder Dams. That much coral, if used for road building, would be equivalent to a two-lane earth highway from New York City to Cleveland, Ohio. And if, for some fool reason, you wanted to pile it all up, it would make a pile 300 feet square as high as a 350-story building. The asphalt surfacing on the field, about 6,800,000 square yards of it, is enough to pave a highway from Boston, Massachusetts, to Washington, D.C.

To Jap civilians on the island, interned at Camp Churo, the entire project must have seemed like the work of the "evil eye" or of some incredible horde of supermen. They were amazed at the speed and fury with which the Seabees tore the earth apart, hauled it about in their monster machines, and pounded it into airfields.

One Tokyo-bred Jap, whose name was Sasaki, was completely fascinated. Every day he watched the island grow, staring at the machines in a kind of awe-stricken way. But for weeks and weeks he stoutly maintained the Japs would retake Tinian,

sweep the Americans away like so many feathers. Then one day he began to weaken. He was worried, morose, and glumly went about his little chores in the confine. This went on for several days, until finally one of our men asked him what he thought about the war. For a minute Sasaki was silent, looking at the ground, stubborn and sullen, pondering his answer. He glanced up. "It's the big scoops." Pressed to say more, he grudgingly admitted that the Americans would hold the island, maybe even win the war.

And to Jap eyes, the "big scoops" were a terrible sight. They could never quite comprehend them. To them the machines seemed like living things, with brains, bones, and flesh of steel. They swarmed about the island like locusts. They were everywhere.

We did have a good deal of equipment. At the peak, the "big scoops" numbered 450 trucks, 55 power shovels, 50 power graders, 125 giant carryalls or "pans," 150 tractors and bulldozers, 75 wagon drills, 12 well-drilling rigs, and 120 air compressors. But every piece was worked night and day, tires were torn to shreds by the sharp, jagged coral. Machine shops were set up along runways so that repairs could be made quickly. And the maintenance job was enough to drive hard-bitten mechanics slightly crazy.

Much more, of course, is involved in building an airfield than the actual strips. For instance, you need bomb dumps. And the Seabees built those nests for the lethal eggs we would hatch out over Tokyo. Then there were tank farms, a regular forest of tanks for the gas that would drive our planes some 1,500 miles to the Jap homeland and back. The tanks held millions of gallons and were tied together with pipe lines for pouring the stuff from one area to another. Around the airfields we built 942 separate structures, everything from control towers, gun towers

and quonset huts, to great warehouses. In addition, living quarters were thrown up for thousands of men. There were chapels, galleys, mess halls, and scores of other buildings, including hospitals with a capacity of 7,000 beds.

We had to have water, and the Seabees gave it to us to the tune of some 1,400,000 gallons a day. They dug 39 wells, put in the pumps, laid the pipe. And the roads, well, the natives have never gotten over the modern highway sweeping around the island. Some seventy miles of coral roads, 20 feet wide, were built, 15 miles of which were dual-strip, four-lane super speedways.

Down on the waterfront, they tackled one of the biggest jobs on the island, building a 4,800-foot-long steel breakwater, dredging a wide, deep channel so our ships could come in, and reclaiming 30 acres of land from the ocean for unloading and storage space. In building their piers, which were big enough for eight deep-draft boats to unload or load simultaneously, they drove 17,000 lineal feet of steel piling. In addition, the Seabees built a marine railway, small-boat repair facilities, and blasted out reefs and coral heads in order to construct ramps for a half-dozen LST's.

You'd think this was enough, that any man would be a little weary and decide to knock off, maybe spend the next year fishing and swimming and dozing out under a palm tree. But Americans are not built that way. It is a kind of instinct, a restless driving force, an urge, or whatever you want to call it, that keeps them building, inventing, bringing to island life the little happy touches of home and cities and Main streets. So they turned to creating the comforts of home. They turned their bulldozers and skill loose on other construction jobs, on building baseball diamonds, theaters, recreation halls, gymnasiums. When they had finished the job there were some fifty theaters for movies or stage

performances; you could play ball on scores of diamonds, play on a dozen or more tennis courts, and swim at any one of four supervised beaches.

35

Magicians and Their Tricks

The construction magic that turned many a flyspeck on the map into powerful naval and air bases didn't just happen with a wave of a wand. It was made up of a multitude of things, a thousand and one factors. Seabee experience on hundreds of construction jobs back home, split-second timing by the Services of Supply, engineering know-how, physical endurance and guts, and ingenuity in overcoming obstacles. Ingenuity of the American construction worker, the little seemingly unimportant tricks of the trade, sometimes helped spell the difference between military disaster and success. They were the hardly mentioned things you seldom saw in the papers, like the method developed for bringing two and even three bulldozers to bear on a tree that resisted the onslaught of one, or the idea put into practice on many an island for knocking down palm trees by stringing a cable between two bulldozers, or the use of ramps that made it possible for bulldozers to push the tops off mountains.

On Bougainville another trick saved the day. Here, Seabees working on the airstrip, sweated through eight days of continual shelling and bombing, yet managed to keep the strip in shape for our planes. At no time was the strip too rough for more than 30-minute periods. It was kept in shape by filling trucks with the exact amount of dirt needed for various-size craters and holding them in readiness. As soon as the Jap bombers left, the trucks would dash out on the strip and dump their loads.

Instead of waiting for equipment and supplies, they'd make

stuff out of discarded junk, sometimes with results that would raise the hair on the heads of your orthodox engineers. Empty oil drums were one of the magic materials. They made everything out of them. With the ends cut out and welded together they were drainage pipe for roads and airfields. At times they were turned into culverts, chimneys, shower baths, furniture, stoves, bathtubs, hot-cake grills, and buoyants for rafts and even for a small floating dry dock. Rolled out flat they became roofing shingles. Stacked on top of one another and welded they became columns for supporting roofs, stages, motion-picture screens. They were cut up for trusses, filled with sand for buttresses, and even, in one instance at least, used for the hull of a canoe, complete with outriggers from Jap plane floats.

The scrap heap was a gold mine. From it one Seabee selected enough odds and ends to make a 23-inch drill press. He did it with an old automobile transmission, 8-inch channel iron, and two screws from the bomb bay of a B-17. The same man turned out a lawn mower, complete with a 2-horsepower motor and a set of tires. Not content with this magic, he then proceeded to make a bolt threader out of an automobile transmission and a pipe vise.

Another time it was essential to make underwater investigations. There was no diving gear. But we had gas masks, and one Seabee, a boatswain's mate, had an idea. Hose was fastened to the apertures in the mask, and air pumped in. The increased pressure in the mask made the air circulate about the face. Highly successful, the outfit was used in depths up to 30 feet.

It didn't make much difference what was needed; the Seabees somehow provided it. At one place they made two dragline buckets by cutting a boiler in two. Each half served as the basis for a bucket. They made cutting teeth from pieces of old narrow-gauge railway track, sharpened and hardened the ends,

and fastened them to the buckets. Then, needing rotary scrapers for a big earth-moving job, they made 'em out of pontoon units, steel boxes measuring 5′ x 5′ x 7″. They made four units out of each box, and made the tongues, sleds, trips, and so forth from scrap metal. The result was a lot of dirt pushed around before the missing equipment arrived.

There are thousands of such examples. All illustrating their ability to improvise and somehow see the job through. Alone they seem insignificant, but in the aggregate they indicate a vital characteristic of our construction worker, a trait that sets him apart from the methodical German following orthodox methods and techniques, and the Jap's detailed imitations of American devices and materials. Although it is impossible to estimate the importance of construction ingenuity in the winning of the war, we can be certain that it often confounded the enemy, and enabled us to strike faster and harder than he believed possible.

36

We Hit the Beaches and Build

AND so the story goes—another island, men wading to the beaches, bulldozers and power shovels chugging up the shore under shell fire, bombings, strafings. Then the building of roads and airfields, camps and harbors. It seems an endless story, microscopic in relation to the arched blue sky and the vastness of the Pacific, tremendous in terms of courage and work power.

Our fleet approaches an island, and suddenly the placid calm of white coral and palm trees and blue lagoons erupts into a quivering mass of sand and mud and water. Trees are knocked about like bowling pins, their jagged arms reaching grotesquely to the sky. Concrete pillboxes are torn out of the earth, tossed about, buried, blasted into heaps of reinforcing iron and chunks of concrete. And the beach is littered with landing craft and upset trucks; bulldozers are turned on their backs, their ugly snouts ripped off, their powerful, crouching bodies a jumbled mass of twisted steel. And on the beaches, half buried in sand and water, are the dead.

Sometimes the story seems as old as the Pacific, a kind of nightmare that has haunted men from the beginning, a horrible cataclysmic bursting open of the bowels of the earth. Then at times, especially when you sit and watch the construction miracle, see the dozers pushing away mountains, the humpbacked carryalls waddling off with loads of coral, the power shovels

ravenously eating at cliffs, you feel that it is the newest story, as fresh as the first day of spring back home.

And it was, of course, a new kind of war—a war that turned the construction genius of the country to building nests for superforts, carving modern highways through jungles, digging and hauling mountains of coral. A war of grading and blasting, welding and sawing, digging and dredging. It sometimes seemed as though the whole war were one vast construction project. Nothing could stop this construction job—malaria, jungle heat, numbing cold, flooding rain, death. American bulldozers marched in Asia, Africa, Europe, and over the vastness of the Pacific. They growled over mountains, cut their way through jungles, swept across deserts. It was like an avalanche or an overpowering tidal wave.

It was made up of shrewd planning and painstaking coordination, breath-taking deeds of courage, heroic sacrifices; but it also was made up of millions of little things, acts, which taken singly may seem relatively unimportant, but which, in the aggregate added up to knock-out punches. In some places it was a matter of building a few hundred feet of road, a short pontoon causeway, a single little airstrip, a small pier, or a bridge. And sometimes these little things suddenly became very important things indeed.

The beach at Rendova, for instance, was so soft that the Marines could not move their heavy artillery over it. Jap Zeros had a picnic swooping down on us and blasting the beach. There was just one thing to do, and the Seabees did it. They hit the beach under a rain of Jap bombs, slashed down coconut trees, and built an old-fashioned corduroy road while the fighting was going on.

On bloody Tarawa they had the job of fixing up a blasted Jap airstrip. They moved in on the strip, and just 72 hours later,

by the time the Marines had crushed the last Jap pillbox, the airstrip was finished and ready for our planes.

Again at Vella Lavella, the Seabees landed with the assault forces. All through the day they worked frantically. They unloaded all equipment and supplies, hauled heavy artillery to emplacements, established supply dumps, and set up a temporary camp. They located a water supply and got it going. And to top it off, they roughed out nine miles of road—all by nightfall on invasion day.

And there was Guam where Jap resistance was so fanatical that construction began under combat conditions. Seabees repaired an airfield while its possession was being challenged by Jap tanks. They worked constantly under sniper fire, many underwent continual air attacks. They turned Guam into a powerful, hard-hitting naval base, built miles and miles of good, heavy-surfaced roads, and five airfields. In Apra Harbor they built one of the Pacific's great anchorages, which required the dredging of many millions of cubic yards of coral and the building of all the complex facilities needed by a modern navy.

On Saipan the story was about the same. Here Seabees and Army Engineers built another large group of airfields, 230 miles of hard-surfaced roads, and water-producing facilities which poured out more than a million gallons a day. They made rest camps for combat troops returning from the Iwo Jima, Okinawa and Philippines campaigns, and they built extensive recreational facilities.

When the time was ripe, or to be exact, on the morning of February 19, 1945, we struck hard at Iwo, a tiny pimple of an island, just 750 miles south of Tokyo. For 74 consecutive days the Pacific Strategic Airforce had bombed it. Every so often units of our fleet had shelled it and let loose their carrier planes on it. It had been pounded day and night, shaken throughout

its entire length of five miles, churned into a shapeless mass of shattered concrete pillboxes, twisted reinforcing steel and black, cindery sand. It was pockmarked, desolate, and evil.

The Marines hit the black beaches at 9 o'clock. And the bitterest struggle in the history of the Corps was on. The fighting raged for 26 long, bloody days, in hundreds of caves, enormous cube-shaped pillboxes, up the face of Mount Suribachi. And the Seabees were in it too, slicing a road up the mountain under strong enemy fire, building the longest airstrip in the Pacific, repairing Jap airstrips, resurfacing the loose sandy beaches. Later, they cut off the top of Mount Suribachi and even harnessed the island's volcanic steam for therapeutic baths.

If the war had lasted much longer, the Japs would have felt such crushing blows from Okinawa that even without the atomic bomb they could hardly have withstood the devastation we would have rained on them, day after day, night after night. Just three hours' flying time from Tokyo, Okinawa would have been the most lethal of all bases in the world. It would have had 22 airfields with 25 miles of runways, and the smallest airfield would have handled twice the traffic of New York's LaGuardia Field. Bombers would have made two trips a day to southern Japan, carrying maximum bomb loads each time. By the end of the war, hundreds of miles of highways already had been built, and bulldozers and dredges were busy developing several anchorages which would have enabled us to launch virtually continuous carrier attacks against the Jap homeland.

The over-all job at Okinawa would have been one of the greatest construction projects ever undertaken. It would have been bigger than the combined operations on Guam, Saipan and Tinian, each of which is one of the great construction achievements of the war.

There were hundreds of big jobs and the Seabees and Army

Engineers will be spinning yarns about them for a long time. The stories will go on and on. Maybe they'll be passed down to their grandchildren and become legends about how a gang of plumbers and carpenters and dozer men and steel workers chased the enemy clean around the world. There will be stories of the way dozers pushed islands up from the sea and the wilderness from under the enemy; stories about the power shovels eating dirt so fast that along with oil they had to be fed bicarbonate of soda. And some of their yarns will seem fantastic; but many of them won't be so very far wrong.

Yet there won't be too many stories, for our construction men will be too busy to tell them all. They'll be spinning their steel cobwebs across rivers, climbing up their steel skeletons, driving their tunnels. They'll be tossing up homes, rebuilding cities, making airfields, carving out roads, and, in general, raising hell with the face of our good earth here at home. In fact, the face-lifting job will be so big that maybe even those huge jobs in the Pacific and Asia and Europe will gradually become remote and nightmarish things. Besides, it's mighty nice, these men say, to be building your own country for your own people.

Seabees built the ramps . . .

U. S.

dozed out airstrips.


322
30

U. S. N

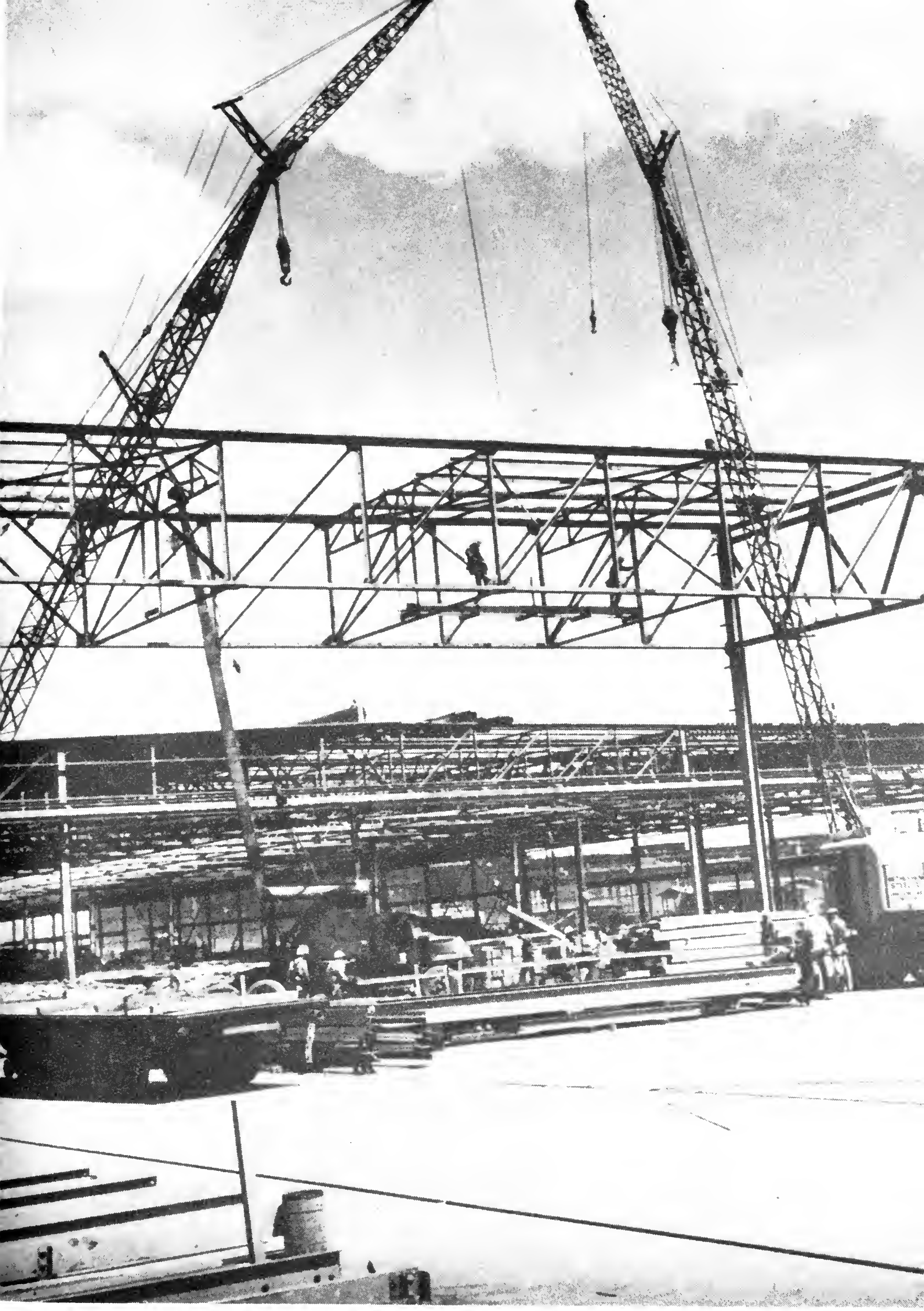
They moved the earth . . .

and built the bases.

U. S. Navy


So when we reach the
"Isle of Japan"
With our caps at a
Jaunty tilt
We'll enter the city of Tokyo
On the roads the SEABEES
Built.
Third Marine Div.
2ND Raider Reg.

U. S. I

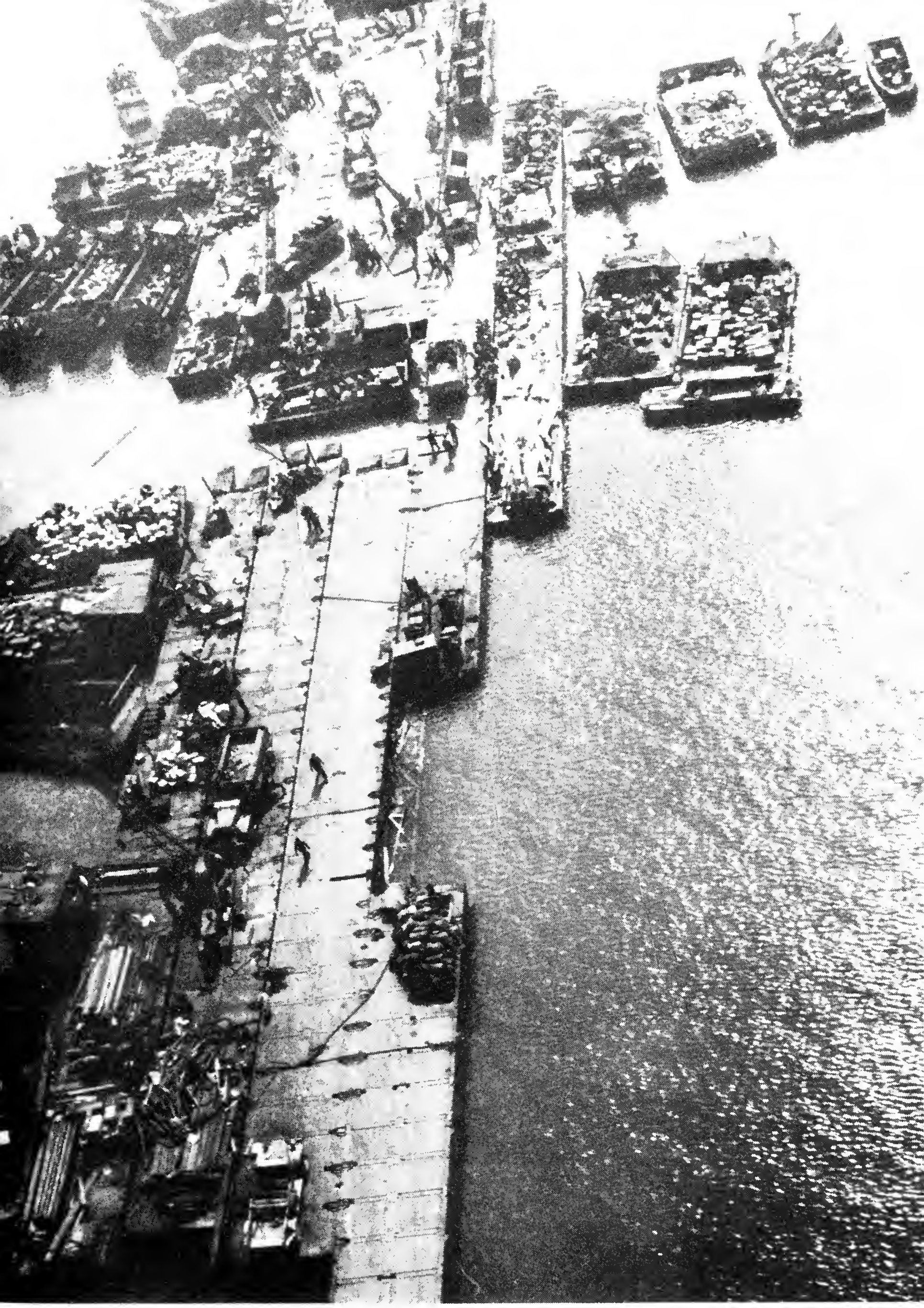


Bethlehem

We built the war plants and ships . . .

U. S.

the drydocks to heal our wounded ladies . . .

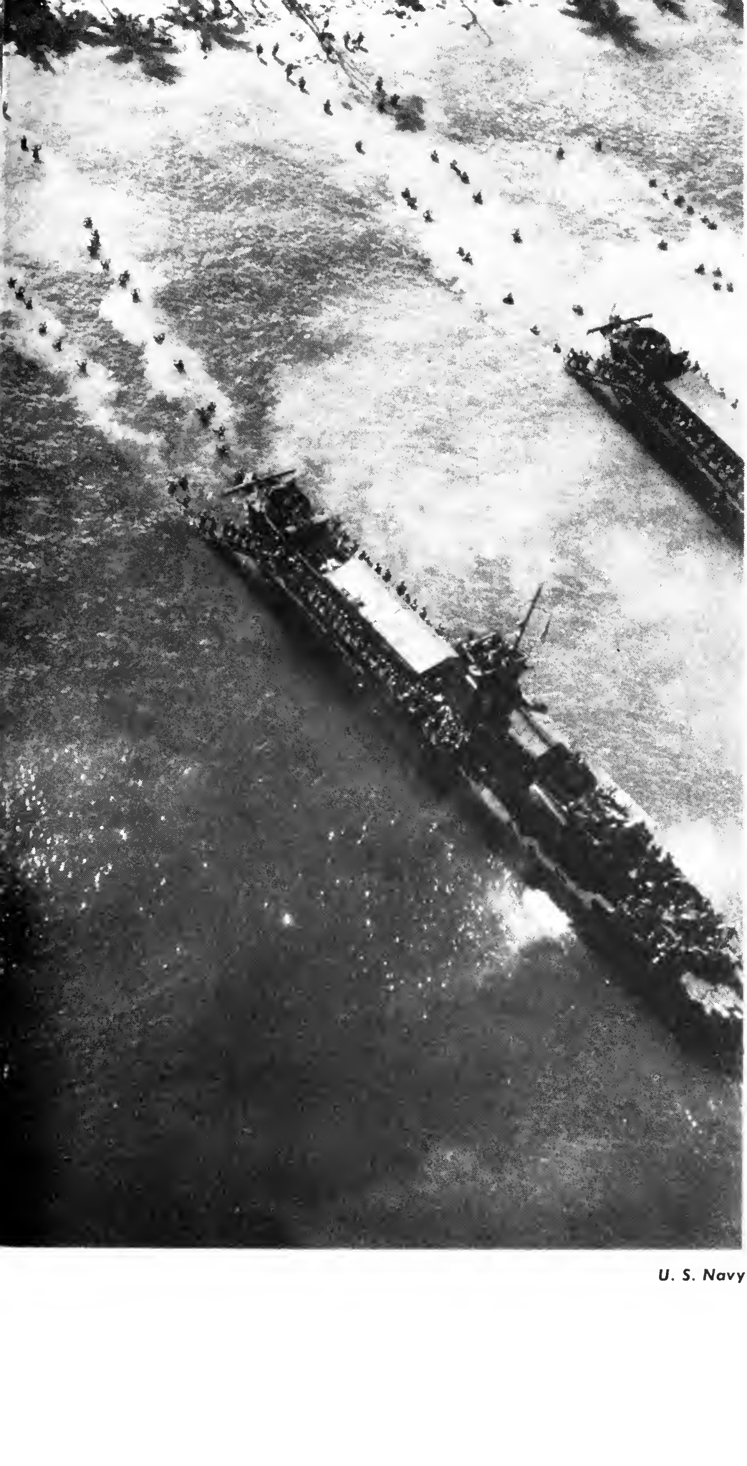


the pontoons for supplies and troops.

U. S

We built the bases . . .

to hit the beaches.



U. S. Navy

Signal

The dozers and shovels and cranes fought the enemy.

PART TWO

WAR CONSTRUCTION REPORTS FROM GOVERNMENT AGENCIES

1

The United States Navy

By Rear Admiral John J. Manning

Chief, Bureau of Yards and Docks

Much was written during World War II about our two-ocean Navy, but very little appeared in print concerning the six-ocean shore establishment needed for that Navy.

The magnitude of the assignment—all apart from its urgency—may be judged by the fact that when the emergency arose American shore establishments were worth about a half billion dollars. When the war ended with all demands satisfied, the Navy's Bureau of Yards and Docks had completed over $8,000,000,000 worth of work.

During the period between the World Wars, naval construction, like all other branches of the military, had been at a virtual standstill. What peacetime projects were undertaken were accomplished by means of lump-sum or unit-price contracts which permitted the preparation of detailed plans and specifications followed by competitive bidding. But when war became imminent, it was apparent that the existing method of negotiating construction contracts was too slow and inflexible to meet demands. What was required was a form of contract that would permit a pooling of the experience, talent, and resources of the country's engineering and construction manpower. To achieve this we made use of "Cost-Plus-Fixed-Fee" contracts, which were to play a great part in the success of the emergency construc-

tion program. The fixed-fee contract enabled our contractors to push ahead with all possible speed and to shift quickly to meet constantly changing requirements. It gave full play to their resourcefulness in meeting war-induced emergencies. The contractors were given a goal and a deadline and the amazing fact is that in practically every case they reached it ahead of schedule.

The lump-sum competitive-bid contract is recognized as the usual Government form of contract, and for that reason, as the peak of construction passed, the Navy restored the use of this type of contract.

Other factors contributed to the success and speed of the program. For example, the Bureau had been planning many of these works for a long time, and much of the basic design work was already accomplished. Then too, the organization of the Bureau in the field was so constituted that it could be rapidly expanded, with broad authority granted to Officers-in-Charge in the field. Still another factor was that when the designing and engineering load exceeded the capacity of the Bureau of Yards and Docks organization, the design work was done under contract by private engineering and architectural firms. Layouts and structures had been so planned that aside from design modifications necessitated by material shortages, designs were fairly well standardized. Contractors constantly devised better and quicker construction methods. At the Naval Training Station at Sampson, New York, for example, a method of erecting the laminated wood arches was devised so that in the last drill hall built, all 62 arches were erected in a single day.

It should be pointed out that most of the factors contributing to the speed of the program could be effected only by the loyal effort of our civilian employees and our greatly expanded Civil Engineer Corps.

The increasing importance of the aircraft carrier necessitated a tremendous increase in Naval airpower and equipment. In 1939, the Navy had but 11 air bases and 8 reserve bases. But by 1942 our growing Naval air force included 27,500 planes, which meant a fast-growing demand for personnel to man those planes, and additional stations at which to house and train new flyers and ground crews. During the building program which followed, 80 air stations and numerous satellite fields were constructed, 38 of them at a cost of over $10,000,000 each. Countless problems were faced in the construction of these stations. In 1942 there was an abnormal rainfall in most parts of the United States. Mud slowed up operations that couldn't afford to be slowed up. At Corpus Christi, Texas, the mud turned to dust and the subsequent dust storms damaged equipment. At Corpus Christi also, a wild burning oil well gave off a salt solution which ate away insulation on wires, burning and shocking workmen. In locations which were isolated from urban populations, labor was scarce and inexperienced. Yet in the face of these and other problems, there was built at Corpus Christi the largest air training center in the world. This $90,000,000 unit now spreads over a 40-square-mile area, and includes a main station, 6 auxiliaries, 45 satellite fields and housing for 29,500 officers, cadets and enlisted men.

The third largest item in the list of emergency expenditures, $1,116,258,384, is the cost of new, war-born facilities for shipbuilding and ship repair. Long before the public was aware of the danger of war in the Pacific, the Navy's engineers began preparations to meet it. Pearl Harbor, the nearest base to Japan, was not equipped to handle such a situation. Its one battleship graving dock had taken five years to build. More were needed but they could not take that long to build. We didn't have that much time. Civil Engineer Corps officers decided to employ the

Tremie method of pouring concrete under water. As a result the second graving dock was completed before the attack on Pearl Harbor and was invaluable in the repair of ships damaged there. Another was completed a short time later. More than 30 other docks have been completed since 1939, some of which can dock the world's largest battleships and carriers.

New construction methods were also developed in expending 430 million dollars for storage warehouses and fuel reservoirs. These included storage tanks built in the interiors of mountains or put underground in the same time that topside installations could have been made—thereby providing protection from bombing and artillery as well.

Expenditures on ordnance plants for production of guns and ammunition for the fleet totaled 471 million dollars, and included such huge projects as those at Crane, Indiana; Hastings, Nebraska; and McAllester, Oklahoma. The smallest of these installations covers 71 square miles.

At the outset of the national emergency the Navy had in service just three floating dry docks, with a total capacity of forty thousand tons. It was quite evident that many ships would suffer serious damage in fulfilling their missions, and the others would suffer the hardest kind of usage. We knew that the quickest and cheapest way to add a ship to the fleet was to repair an existing one. But to do that we had to have repair facilities close at hand. So, with the support of private industry, we went to work. By V-J Day we had one hundred and fifty-five floating dry docks with a lifting capacity of more than one million two hundred thousand tons. Four hundred million dollars may seem a large sum to have spent for these floating dry docks, but no money was ever more wisely invested. In the last year of the war, they serviced approximately 7,000 ships, including the largest battleship in the world.

Much of this gigantic program of construction was carried on despite a critical lack of essential materials. But whenever it was needed, ingenuity overcame the difficulty and construction went on. Among the steel-saving designs were those for all-wooden hangars for lighter-than-air craft, and the use of concrete for oil storage tanks, and for certain types of floating drydocks.

Prior to the war all of our construction work was performed by civilian contractors. In 1940 and 1941 the extensive developments undertaken at Pearl Harbor, at Midway, Guam, in Samoa, the Philippines, and at Wake were being performed by such contract work, and with excellent results.

But the attack on our Pacific possessions by the Japs in December of 1941 emphasized the need for quickly militarizing our construction forces. Civilian workers had neither the training nor the weapons with which to defend themselves, and even if they had, they would have been under a great handicap. In the event of capture, an armed civilian has no status as a Prisoner-of-War. His status is that of a guerilla and if captured he can be summarily executed. Furthermore, under combat conditions, military discipline is essential. And so there came into being the Naval Construction Battalions, popularly known as the "Seabees."

Our Seabees were a new development in Naval organization and it is probable that no one realized to the full extent how significant their role in the war would be. Their number grew to approximately 250,000, and so great was their contribution to the prosecution of the war that it has now been decided to continue the Construction Battalions as an integral part of the U.S. Navy.

The key to the success of the Seabees as an organization lay in the character of its personnel.

They were not novices who were taught quickly and superficially their wartime jobs. A large percentage were skilled workers who had learned their trades through years of experience in private industry. The result of the training that civilian labor had given them was the ability to perform with speed and efficiency.

The Construction Battalions thus represented a major contribution on the part of the civilian construction industry. The work of these battalions at advance bases, added to the work of civilian contractors on domestic projects, provided that example of teamwork among labor and industry and government that the future welfare and safety of our country requires.

The construction fraternity made a major contribution to the winning of the war and has won the acclaim of the country.

STATUS OF NAVY'S WARTIME SHORE CONSTRUCTION PROGRAM
July 1, 1940 to December 31, 1945

CLASSIFICATION	AUTHORIZATIONS RELEASED	TOTAL OBLIGATED	REPORTED VALUE OF WORK DONE
Shipbuilding and Repair Facilities	$1,208,106,523	$1,205,310,853	$1,116,258,384
Fleet Facilities	258,318,090	258,318,090	226,697,414
Aeronautical Facilities	1,659,076,042	1,659,076,042	1,613,264,208
Ordnance Facilities	892,022,974	892,022,974	798,681,328
Storage Facilities	535,639,028	535,639,028	495,195,042
Structures for Naval Personnel	600,245,023	600,245,023	561,998,145
Marine Corps Facilities	197,673,407	197,673,407	184,959,709
Radio Facilities	38,820,683	38,820,683	35,408,866
Hospital Facilities	211,185,502	211,185,502	191,458,116
Section and Frontier Bases	45,943,983	45,943,983	45,399,685
British Bases	133,020,898	133,020,898	131,428,159
Advance Bases	2,813,571,828	2,766,452,407	2,283,240,870
Defense Housing	86,434,129	86,125,925	84,095,971
Naval Working Fund	222,276,601	222,276,601	146,836,750
Structures Not Otherwise Classified	271,983,649	262,545,506	235,837,092
Not Distributed	24,447,491	24,447,491	——
* TOTAL	$9,198,765,851	$9,139,104,413	$8,150,759,739

* The discrepancy between the authorizations released and the reported value of work done is attributable in part to the fact wartime conditions delayed completion reports. The war's end resulted in the cancellation of many intended projects, and the appropriations, contractual authorizations and prior year unreverted appropriations were greatly reduced by Congress.

2

The United States Army

BY LIEUTENANT GENERAL RAYMOND A. WHEELER

Chief, Corps of Engineers

MODERN warfare is essentially a war of logistics—of production, transport, and supply, of increasing the combat power of friendly troops by both construction and destruction, and of facilitating the movements of friendly troops while impeding those of the enemy. It is, in short, what General MacArthur has called an "engineers' war." In the final analysis, it is the engineer who must marshal a nation's work-power at its greatest and speediest efficiency and place it at the disposal of the military command.

In World War II, the marshaling of American work-power, the providing of design, material, and equipment needed to construct war plants, posts, camps, stations, airfields, utilities, pipe lines, storage facilities, roads, docks, bridges, and other essential construction in both this country and wherever over the world our Army needed them, constituted what has justly been called the greatest challenge ever flung at the American engineering profession. Proof that the challenge was met fully, and with a speed and efficiency which eventually collapsed the strategic timetables of the unbelieving enemy, is recorded in two great days—V-E Day and V-J Day. Undoubtedly, the achievement is the most brilliant feather in the American constructor's already well-plumed hat. It was an all-American job, with civilian and

military engineer, architect, and contractor working together, getting the job done, and on time.

War found the Corps of Engineers, U.S. Army, ready as a true representative of American scientific and technical genius. This preparedness was due in large measure to the dual, and unique, role of the Army Engineer in the life of the nation. Unlike Army Engineers of other countries, the U.S. Army Engineers are as active in the service of the country during peacetime as in wartime. Simultaneously, they serve the Army as one of its oldest and largest technical services and the Congress as the nation's largest Engineer Department. The Engineers have charge of all river and harbor improvements and maintenance, and the nation's great program of flood control. Thus, left with no time in which to grow rusty from disuse, the U.S. Army Engineer must, by the very nature of his military and civil duties, keep on a practical working basis with practiced skills and all phases of modern engineering.

Details of the nation's war construction program, both at home and abroad, are given elsewhere in this volume. It suffices here only to state in quick summary certain broad, illuminating facts. For example, in this country alone, the Corps of Engineers, working through its division and district offices, and in cooperation with civilian contractors, completed approximately 3,000 command installations, some 300 major industrial projects, and hundreds of miscellaneous industrial facilities. The installations included 500 camps, 765 airfields, 167 storage depots, and numerous training schools, ports of embarkation, hospitals, and other facilities. In aggregate, approximately 11 billion dollars were expended on construction. And not only did the Engineers build these installations, but they also continued on the job and maintained them.

Almost every engineer, architect, and contractor in the United

States was engaged in the construction program, at one time or another. The Office of the Chief of Engineers has record of working with 5,300 contracting firms and 300 architect-engineer firms. In addition, the Corps of Engineers reached a wartime strength of more than 700,000 men, with nearly 500,000 of them serving overseas. Many of these men, who did such a fine war job, were recruited from the construction industry. All of them received sound training and very practical experience and are today a valuable asset to the country in its great peacetime construction program.

Concurrently with war construction in the continental United States, major projects were undertaken in such outlying bases as the Azores, Trinidad, Newfoundland, Hawaii, Panama, Bermuda, Brazil, Iceland, and other places, as well as in all overseas theaters of operations.

It is today axiomatic that without the Engineers, infantry cannot move onto foreign beaches, armored forces cannot surmount enemy fortifications or bridge hostile waters, and planes cannot advance beyond their initial bases. Behind the force that landed on the Normandy beaches were two years of American work-power, two years of production at home and of building supply lines and fighting bases in Great Britain. In England, the Engineers built all the construction needed—with the exception of Signal Corps installations—to house, equip and train the world's greatest invasion army. In addition, the Engineers constructed large scale models and detailed maps of what assault troops would find when they hit the beaches. All military maps in all theaters of operations were prepared, printed, and distributed by the Engineers, often constituting the first modern, up-to-date maps of the area. For the invasion of France alone, the Engineers furnished 116 million military maps.

On every battle field the world over, the Engineers kept the

armies moving. To accomplish this gigantic, globe-circling job, they constructed a chain of ports and anchorages, and lay a carpet of airfields round the world. The rate at which the Engineers often were called upon to build airfields, for example, is well illustrated by the fact that in Belgium and France the IX Air Force Engineer Command built 100 fields in 90 days. Often, in both Europe and Asia, fields were laid down ahead of the infantry.

There is no way of reckoning the miles of roads constructed for the transportation of men, supplies, and ammunitions. Some of the roads, such as the Ledo Road into China, received worldwide acclaim, all of them were important and contributed to our final victory. And roads called for bridges. It has been said the Allies rolled across France and into Germany on a chain of Bailey Bridges, laid down in advance of even the armored troops and often under fire. Bailey Bridges are today contributing to peacetime road construction and repair, while new methods gained in constructing every type of bridge, under often unbelievable conditions, have added valuably to the U.S. constructor's technical skill and knowledge.

A sufficient number of miles of railroads was constructed overseas to link New York City and Tokyo with a double-track line. When time was the essence, immediately following the St. Lo "breakthrough" of General Patton's Third Army, five Engineer regiments performed a miracle in railroad construction. These regiments rebuilt 60 miles of railways, marshaling yards, 7 bridges, cleared demolished tunnels, and restored water points—all within two days.

Also keeping pace with General Patton were the pipeline Engineer troops, who laid from fifteen to fifty miles of line a day in France, and built a supply line into China that many experts said couldn't be done. The oil pumped to and across

France, incidentally, wasn't transported to France by tankers; it was piped across the Channel from England by way of another engineering "miracle" of the war. A total of 11,000 miles of pipeline were laid—enough to supply the normal consumption of oil for half the United States in peacetime.

The Engineers built and rebuilt great seaports—enough of them to handle more tonnage than New York, Boston, and San Francisco combined. Cherbourg is an example. The Germans left Cherbourg completely ruined and useless, or so they thought. Yet, in a matter of days, the Engineers had the port in full operation, and by V-E Day they had it actually handling more tonnage than ever before in its existence.

In the Pacific theater of operations, the Engineers were faced with difficulties vastly different from those found and overcome in Europe. In Europe, the British Isles formed a base from which to mount our invasions. In the long reaches of the Pacific there was nothing except volcanic islands and jungles. The Engineers had to start from scratch. With heavy equipment, they literally tore the jungle tops off the islands and built bases, camps, airfields, and ports. The very tempo of the war against Japan was measured by the speed with which Army Engineers were able to construct the far-flung staging areas and bases for operations. Engineers, who at home built the great secret laboratories, plants, and, in fact, the "city" in which the atom bomb was produced, also built the fields from which rose the planes carrying the bombs to Japan.

Now that peace has returned, the Corps of Engineers has returned to its peacetime assignments as the nation's largest and oldest engineer department. Under direction of the Congress, it has begun work on the largest and farthest reaching, long-range construction program in the country's history. As there recently was a part for all members of the construction industry

in our gigantic building for war, so is there today a place in the current building for peace. What each member of the engineer and construction professions thinks, and what each member does individually and in cooperation with others to aid this program, will determine the evaluation history gives to our accomplishments. A greater participation in civic life and civic planning is an opportunity which no one engineer, contractor, and architect-engineer should neglect. The prosperity and happiness of our nation is dependent in large measure on our success.

WAR CONSTRUCTION PROGRAM
JOBS COMPLETED IN CONTINENTAL UNITED STATES AND WORK PLACED OUTSIDE CONTINENTAL UNITED STATES

	WAR CONSTRUCTION JOBS COMPLETED IN THE CONTINENTAL UNITED STATES *		
YEAR AND MONTH	NUMBER	ESTIMATED COST (Thousands)	VALUE OF WORK PLACED ON JOBS OUTSIDE THE CONTINENTAL UNITED STATES (Thousands)
1941			
December	75	$ 168,267	$ 5,977
1942	2,091	4,937,617	183,375
January	23	117,784	5,977
February	45	149,219	5,995
March	79	222,898	8,590
April	81	321,080	8,991
May	90	298,608	13,133
June	121	667,770	14,939
July	90	263,134	15,823
August	89	267,496	20,366
September	128	522,338	21,807
October	123	460,026	22,541
November	418	678,162	22,602
December	804	969,102	22,611
1943	13,014	3,393,109	461,476
January	931	380,155	16,765
February	914	459,264	9,865

* Does not include 106 Civil Aeronautics Authority and Aircraft Warning Station jobs completed prior to October 1942 and 441 passive protection jobs completed prior to January 1943, for which data are not available.

WAR CONSTRUCTION PROGRAM
JOBS COMPLETED IN CONTINENTAL UNITED STATES AND WORK PLACED OUTSIDE CONTINENTAL UNITED STATES (CONTINUED)

YEAR AND MONTH	WAR CONSTRUCTION JOBS COMPLETED IN THE CONTINENTAL UNITED STATES: NUMBER	WAR CONSTRUCTION JOBS COMPLETED IN THE CONTINENTAL UNITED STATES: ESTIMATED COST (Thousands)	VALUE OF WORK PLACED ON JOBS OUTSIDE THE CONTINENTAL UNITED STATES (Thousands)
March	1,097	$ 271,397	$ 14,943
April	1,115	342,534	35,053
May	1,102	366,798	32,386
June	1,220	374,610	29,841
July	1,299	292,737	47,641
August	1,784	117,613	62,381
September	1,114	191,455	54,261
October	822	257,110	63,769
November	875	176,378	75,185
December	741	163,058	19,386
1944	3,997	806,353	68,487
January	461	282,160	9,814
February	404	23,364	14,404
March	405	136,502	11,200
April	305	33,027	11,160
May	284	51,301	3,846
June	271	38,535	4,027
July	259	40,260	3,745
August	302	50,412	3,282
September	386	39,313	1,038
October	314	44,212	2,482
November	279	39,713	1,356
December	327	27,554	2,133
1945	2,660	473,234	10,094
January	287	42,832	1,541
February	229	24,104	1,740
March	316	33,604	1,953
April	255	28,949	2,601
May	325	38,054	167
June	388	38,166	1,510
July	341	44,215	303
August	519	223,310	279
TOTAL	21,837	$9,778,580	$729,409

3

The Reconstruction Finance Corporation

By Charles B. Henderson

Chairman

UNDER the National Defense Act of 1940, the Reconstruction Finance Corporation was authorized to make loans to, or to purchase the capital stock of, any corporation for plant construction, expansion and equipment, and working capital, to be used by the Corporation in the manufacture of equipment and supplies necessary to the national defense. It was further authorized to create or to organize a corporation or corporations with power, among other things, to purchase and lease land and plants, to build and expand plants, and to purchase and produce equipment, supplies and machinery, for the manufacture of arms, ammunition and implements of war; to lease such plants to private corporations to engage in such manufacture; and, where necessary, to engage in such manufacture itself.

Three days after this enactment, or on June 28, 1940, RFC created as subsidiaries the Rubber Reserve Company and the Metals Reserve Company. Within two weeks the Corporation authorized its first defense loan under the Act. Two additional wartime subsidiaries were established soon thereafter; the Defense Plant Corporation on August 22, 1940, and, one week later, the Defense Supplies Corporation.

RFC's program of constructing and equipping plants, and of

installing facilities in privately owned plants for war production work, was concentrated largely in the Defense Plant Corporation (see Table I). Of approximately $10 billion of RFC authorizations for this purpose, commitments of nearly $9 billion were under direction of Defense Plant Corporation. Construction of facilities needed in projects sponsored by Metals Reserve Company and Defense Supplies Corporation was directed almost in its entirety by Defense Plant Corporation, and the entire construction program of facilities sponsored by the Rubber Reserve Company was handled by Defense Plant Corporation.

From August 22, 1940, through December 31, 1945, Defense Plant authorized projects totaling $8,972,532,000 for constructing and equipping war facilities; Defense Supplies authorized $272,335,000 in the form of advances to petroleum refiners for the construction of aviation gasoline refineries; Metals Reserve authorized $7,797,000 for investment in mining facilities, in addition to which it authorized mining development loans and advances totaling $130,365,000, of which all but $5 million was authorized to projects located outside the continental United States. Over and above these amounts, the Reconstruction Finance Corporation itself authorized loans involving $530,340,000 of construction, equipment and machinery, including loans to contractors. This amount includes thousands of business loans to small suppliers and subcontractors, as well as larger defense loans for the purpose of financing companies engaged in the construction, principally, of gasoline, aluminum, and steel plants. RFC authorizations for war facilities of nearly $10 billion represented about half of all Federally financed projects during the period for the expansion of industrial manufacturing facilities, the total authorized by all Federal departments and agencies having been estimated by the Civilian Production Administration at over $18 billion.

RFC constructed or equipped over 2,000 industrial plants for use in war production. In addition, it constructed and equipped 62 flying schools and 150 other facilities essential to the war effort. The majority of RFC-financed plants were leased to private industry for operation, although a number of important projects, such as the $200-million Geneva steel plant, the Texas City tin smelter, and the approximately $700-million synthetic rubber plants, were operated by private organizations for the account of the Reconstruction Finance Corporation.

Wartime construction of practically all of the Nation's facilities needed for the manufacture of aluminum and magnesium, and all of these required for producing high-octane gasoline and synthetic rubber was financed by RFC, acting under directions from other governmental agencies. Three-fourths of the wartime expansion of steel, pig iron, aircraft, and machine tool manufacturing facilities resulted from projects directed by RFC. Of total Federal authorizations for the construction of additional transportation facilities, two-thirds were RFC-handled, these activities included the "Big Inch" and "Little Big Inch" pipe lines, which, at a time when the German submarine menace was at its worst, brought mid-continent oil production within reach of the industrial East. More than one-half of Federal authorizations for the construction of facilities needed in the manufacture of chemicals were RFC-authorized. Unique in the American industrial field was RFC's wartime project of financing construction of the Texas City tin smelter for treating South American ores and insuring a wartime supply of this basic metal in the United States which, before the war, had never produced as much as one per cent of its requirements of tin.

As a collateral development of its wartime construction activities, RFC, early in the war, began placing orders for machine tools in order to guarantee a ready market later to

manufacturers of machine tools. As soon as these tools were sold by the makers to industrial manufacturing customers, RFC's obligation under the orders was canceled. By placing a backlog of firm Government orders in the market, well ahead of time, in order to meet contemplated later production requirements, thousands of machine tools were available on relatively short notice at a time when they were critically needed by industry to perform under rapidly mounting war contracts. Under this plan of pre-season buying, RFC issued total machine tool order commitments of roundly $1,900,000,000. Nevertheless, RFC's net investment in tools, which it was required to take up under these orders, amounted to less than $3 million.

Authorizations made by RFC and its subsidiaries embraced virtually every type of industrial production facility and a wide variety of special war production purposes (see Table II). These included plants and facilities to produce aircraft, aircraft engines and parts; aluminum, aviation gasoline, chemicals and machine tools; magnesium and minerals; guns, tanks, shells, bombs, and other ordnance; ships and parts, steel and pig iron, synthetic rubber, and industrial machinery; hemp and other rope fibers, and medical supplies.

Close cooperation by industry with Government made it possible for the Nation to increase vastly its production for war, and to accomplish this phase of the program in the early years of conflict when all types of matériel were critically needed. Plans for needed construction were drafted and approved with minimum time loss; authorizations increased sharply in the months immediately following Pearl Harbor (see Table III). Government and the construction industry moved swiftly to meet the Axis challenge.

All RFC-owned facilities were provided by RFC at the direction of other Government agencies. The War Department and

the War Production Board were the largest sponsors. (See Table IV). In approximately 70 per cent of these cases the sponsoring agency agreed to immediately reimburse RFC for a fixed percentage of the cost of facilities with the understanding that it would reimburse the Corporation with the remainder of the cost at a later date, provided appropriations were made available for that purpose. These were known as "take out agreements."

On December 31, 1945, approximately $2 billion was due from sponsors under these "take out agreements" and negotiations are continuing to determine the ultimate disposition of such agreements.

RFC's investment in land, plants, machinery and facilities in the defense plant program aggregated $6,763,000,000 on June 30, 1945. This figure was reduced to approximately $6 billion by June 30, 1946, and is expected to be further reduced to approximately $4 billion by June 30, 1947. This latter amount is exclusive of $673,000,000 which RFC has invested in the synthetic rubber program.

RFC's wartime subsidiaries primarily involved in defense construction of plants and facilities—including Defense Plant Corporation, Metals Reserve Company, and Defense Supplies Corporation—were dissolved July 1, 1945, under the provisions of Public Law 109, 79th Congress, approved June 30, 1945, and their functions were merged with the Reconstruction Finance Corporation. Rubber Reserve Company was similarly dissolved, and consolidated into RFC proper, and is continuing to fill its postwar function as RFC's Office of Rubber Reserve.

TABLE I

SUMMARY OF RFC AUTHORIZATIONS IN CONNECTION WITH CONSTRUCTION AND EQUIPPING OF DEFENSE AND WAR FACILITIES, JUNE 25, 1940–DECEMBER 31, 1945—BY AGENCY AND USE OF FUNDS
(Thousands of Dollars)

	AMOUNT AUTHORIZED			
AGENCY	Total	Construction [6]	Machinery and Equipment [7]	Other
Total—RFC and Subsidiaries [1]	$9,783,004	$3,371,115	$6,159,166	$252,723
Reconstruction Finance Corporation [2]	530,340	347,830	72,589	109,921 [8]
Defense Plant Corporation [3]	8,972,532	2,992,698	5,837,032	142,802 [9]
Defense Supplies Corporation [4]	272,335	29,957	242,378	...
Metals Reserve Corporation [5]	7,797	630	7,167	...

[1] The Defense Plant Corporation, Defense Supplies Corporation, and Metals Reserve Corporation were absorbed in the parent organization on July 1, 1945, and are now known as the Office of Defense Plant, Office of Defense Supplies, and Office of Metals Reserve.

[2] Represents the amount loaned to business enterprises for new facilities or additions to existing facilities, and includes participating banks' share amounting to $26,999,000. Excluded are RFC loans to its subsidiaries as well as loans to business enterprises (other than building contractors) for such purposes as working capital or payment of debts which did not involve the creation of additional facilities.

[3] Facilities acquired by the Defense Plant Corporation were Government-owned and were operated privately under lease or management agreement. Data exclude $2,004,587,000 approved for machine tool, gauge and cutting tool programs, as well as $1,125,000 approved for surplus machinery warehouses.

[4] Represents loans made by Defense Supplies Corporation to petroleum operators for the building of refining facilities for aviation gasoline production.

[5] Represents facilities owned by the Metals Reserve Corporation. Excluded are loans and advances for mining development totaling $130,365,000, of which only $5,000,000 was authorized to locations within the continental United States.

[6] Includes buildings, building installations, rehabilitation and rearrangement.

[7] Includes production equipment, rail and automotive equipment and portable tools.

[8] Represents loans to contractors engaged in defense and war construction work.

[9] Represents authorizations for acquisition of land.

TABLE II

SUMMARY OF RFC AUTHORIZATIONS IN CONNECTION WITH CONSTRUCTION AND EQUIPPING OF DEFENSE AND WAR FACILITIES, JUNE 25, 1940–DECEMBER 31, 1945—BY TYPE OF FACILITY AND AGENCY
(Thousands of Dollars)

TYPE OF FACILITY	AGENCY				
	Total RFC and Subsidiaries	Reconstruction Finance Corporation	Defense Plant Corporation	Defense Supplies Corporation	Metals Reserve Corporation
Total	$9,783,004	$530,340	$8,972,532	$272,335	$7,797
Manufacturing Facilities	9,081,647	334,609	8,466,906	272,335	7,797
Aircraft, Aircraft Engines, and parts	3,247,967	40,606	3,207,361	...	...
Aluminum and Magnesium	1,351,365	60,066	1,291,299	...	...
Aviation Gasoline	651,744	55,272	324,137	272,335	...
Chemicals	220,212	6,384	213,828	...	...
Machine Tools	93,544	2,605	90,939	...	...
Minerals	191,522	5,272	178,453	...	7,797
Ordnance	501,572	6,361	495,211	...	...
Radio and Communication Equipment	121,449	1,850	119,599	...	...
Shipbuilding	219,894	19,067	200,827	...	...
Steel and Pig Iron	1,259,978	112,349	1,147,629	...	...
Synthetic Rubber	1,055,671	...	1,055,671	...	...
Other Manufacturing	166,729	24,777	141,952	...	...
Non-Manufacturing Facilities	701,357	195,731	505,626	...	...
Flying Schools	54,446	7,040	47,406	...	...
Transportation	483,324	60,265	423,059	...	...
Housing	92,457	62,961 [1]	29,496	...	...
Miscellaneous	71,130	65,465 [2]	5,665	...	...

[1] Represents loans to contractors engaged in the construction of defense and war housing.

[2] Represents loans to contractors engaged in defense and war construction other than housing ($46,960,000) and unclassified projects ($18,505,000).

TABLE III

RFC AUTHORIZATIONS IN CONNECTION WITH CONSTRUCTION AND EQUIPPING OF DEFENSE AND WAR FACILITIES, JUNE 25, 1940–DECEMBER 31, 1945—BY DATE OF AUTHORIZATION AND USE OF FUNDS
(Thousands of Dollars)

	AMOUNT AUTHORIZED				
DATE OF AUTHORIZATION	Total	Construction	Equipment	Land (DPC Projects)	RFC Loans to Construction Contractors
Total	$9,783,004	$3,371,115	$6,159,166	$142,802	$109,921
1940					
3rd Quarter	31,380	14,147	16,785	425	23
4th Quarter	289,626	92,052	191,755	4,344	1,475
1941					
1st Quarter	185,501	45,458	136,904	1,742	1,397
2nd Quarter	282,057	116,628	155,043	10,351	35
3rd Quarter	679,226	213,575	453,443	11,226	982
4th Quarter	636,138	170,373	439,513	26,097	155
1942					
1st Quarter	2,599,098	727,149	1,836,971	27,752	7,226
2nd Quarter	1,616,729	454,778	1,136,708	11,792	13,451
3rd Quarter	552,426	242,979	289,649	7,370	12,428
4th Quarter	378,579	255,056	107,346	4,984	11,193
1943					
1st Quarter	690,872	464,427	205,528	9,893	11,024
2nd Quarter	276,041	44,037	221,591	3,941	6,472
3rd Quarter	284,323	210,858	61,276	4,247	7,942
4th Quarter	254,521	91,320	153,929	3,855	5,417
1944					
1st Quarter	263,056	109,166	141,429	3,320	9,141
2nd Quarter	175,882	13,482	150,347	2,433	9,620
3rd Quarter	111,909	27,553	81,353	1,648	1,355
4th Quarter	45,824	6,886	36,005	673	2,260
1945					
1st Quarter	285,987	52,213	227,533	4,530	1,711
2nd Quarter	115,284	9,973	98,317	1,751	5,243
3rd Quarter	26,582	8,357	16,457	397	1,371
4th Quarter	1,963	648	1,284	31	...

TABLE IV

DEFENSE PLANT CORPORATION AUTHORIZATIONS IN CONNECTION WITH CONSTRUCTION AND EQUIPPING OF DEFENSE AND WAR FACILITIES, AUGUST 22, 1940–DECEMBER 31, 1945—BY SPONSORING AGENCY
(Thousands of Dollars)

SPONSORING AGENCY	AMOUNT AUTHORIZED
Total	$8,972,532
War Department [1]	4,156,536
Navy Department [1]	694,119
Maritime Commission	104,823
War Production Board [1]	2,396,612
Petroleum Administrator for War	525,713
Rubber Reserve Company	836,304
Office of Defense Transportation	155,099
Other Agencies [2]	103,326

[1] Includes joint sponsoring arrangement with other agencies.

[2] Includes Department of Agriculture, Commodity Credit Corporation, Metals Reserve Corporation, Solid Fuels Administration, Civil Aeronautics Authority, Office of Strategic Services, Office of War Information, War Shipping Administration, Foreign Economic Administration, Treasury Department, War Relocation Authority, and National Housing Administration.

4

The Veterans Administration

By General Omar N. Bradley
Administrator of Veterans' Affairs

Veterans Administration will undertake the largest hospital construction program in history in order to provide medical care for the 20,000,000 veterans of all wars who eventually will be eligible for such care.

But the need for the program actually began on Sunday, December 7, 1941, when the Japanese bombed Pearl Harbor and plunged America into a world-wide war.

From that day on, our nation whipped into shape an armed force of 12,500,000 that was destined to defeat enemy troops seasoned by years of training and war.

The victory was costly. Several hundred thousand men gave their lives and a far greater number were disabled, physically or mentally.

At the beginning of the war, VA had 80,000 beds in its hospitals and homes. This was but half of the number needed for the thousands of disabled men who poured back into the United States throughout the war, as well as for those who required hospitalization for nonservice-connected illness.

During those years, VA realized that only an extensive hospital construction program could furnish adequate facilities for these veterans and for the increased load of veteran-patients anticipated after the war.

However, the actual wartime hospital construction slowed down because of two major factors:

1. Since VA was not considered an essential war agency, it received a low Federal priority rating; and,

2. Because it could not obtain higher priorities, VA experienced difficulties in getting labor and materials.

Notwithstanding these handicaps, VA erected two general medical and surgical hospitals during the war at Fort Howard in Baltimore, Md., with 389 beds, and at West Roxbury, Mass., with 319 beds.

VA took other steps to attempt to meet the rapid and heavy demands for hospital beds.

During the war period, it increased its capacity for neuropsychiatric patients by 10,000 beds through the construction of NP additions to established hospital facilities, through the conversion of VA homes at Togus, Me., and Wadsworth, Kan., to NP hospitals, and by converting Fort Meade, S.D., which VA acquired from the Army, into a 721-bed NP hospital.

To compensate for the loss of domiciliary beds at Togus and Wadsworth, the Army transferred posts at Salina, Kan., and Fort Washington, Md., to VA. The Salina post, of temporary construction, was used by VA for only a short time, but the Fort Washington post was altered to accommodate 437 domiciliary beds, in addition to 68 hospital beds for domiciliary veterans.

VA increased its capacity for tubercular cases by 826 beds, by altering hospital buildings at Oteen, N.C., Tuscon, Ariz., Sunmount, N.Y., and Castle Point, N.Y. It removed walls which separated porches from wards, and extended ward partitions to the porches, thereby converting porches to parts of the wards.

These expedients still were inadequate to care for the wartime patient load, so VA was forced to adopt emergency practices

such as adding more beds to wards and placing others on sun porches. Obviously, this meant overtaxing hospital facilities, not an ideal medical practice but necessary to meet the emergency.

All of VA's wartime construction activities were completed in strict compliance with wartime emergency specifications. Design stresses for steel and concrete construction were increased, and critical materials necessary in the prosecution of the war were avoided whenever possible.

VA construction engineers discovered that several substitute materials and procedures adopted during the war proved superior to the originals, so VA intends to continue using them in the future.

With the end of the war, VA's problem of priorities faded to insignificant proportions in comparison with the immense problem of providing hospitalization for about 150,000 veterans who were expected to apply for it.

This second problem, too, appeared small when VA looked 20 to 25 years into the future and estimated about 300,000 veterans requiring VA hospital care. This figure is based on the same rate of hospitalization VA had in 1940, and considers First World War experience, actuarial estimates and current legislative estimates.

VA took its historic step toward providing veterans with adequate hospital care in February, 1946, when it announced the greatest hospital construction program in the history of the world. Recently estimated to cost about $773,000,000, the program would result in 177 permanent hospitals of all types with a total capacity of 142,000 beds. When the program is completed, VA will possess a total of 205 hospitals and homes, containing 162,321 beds for general medical and surgical, neuropsychiatric, tuberculosis and domiciliary purposes.

Two NP hospitals already are under construction at Lebanon, Pa., and Tomah, Wisconsin.

Many of the new hospitals will be built vertically, in the form of skyscrapers, instead of horizontally over acres of land. This new concept of hospital construction will be carried out especially in crowded cities where land values are high.

The new program also requires hospitals to be built close to medical schools and centers whenever possible so that doctors and other professional people can be brought into part-time association with VA's medical program and help it attain its goal of a medical care for veterans second to none.

Hospitals obviously cannot be built overnight. VA surveys show that in the past, 1,080 days elapsed from the time the proposed site was surveyed until the first patients entered the hospital.

Although the new program will be handled in an accelerated manner, considerable time will pass before the new hospitals can accommodate patients. Until then, VA has made arrangements with the Army and Navy to use their hospital facilities whenever available and whenever sufficient personnel can be secured.

When the construction program is completed, veterans will be assured of the world's finest medical service, staffed by the nation's most skilled medical personnel.

The service is not being "given" to them as a dole or charity. It is something that they have deserved because of their faithful service to their country.

The best hospital care is the least we can do for them.

5

The National Housing Agency

By Wilson W. Wyatt *

Administrator and Housing Expediter

During the war the United States housing supply became a national resource which was shaped to the needs of war by the cooperative efforts of industry, labor and government. Through these efforts housing became an ally of war production, its condition and quantity vitally affecting our aims and existence as a nation. The story of war housing is a story of one of the greatest planned migrations of a free people in history, with war housing providing shelter for more than 4,000,000 war workers and their families.

While the beginning of war housing dates from about the middle of 1940, it was not until February 1942 that the National Housing Agency was established by Executive Order incorporating all non-farm housing functions of the Federal Government. As a result, a single government agency was charged with the responsibility of unifying war housing activities and directing the construction of all home building toward the needs of immigrant war workers.

Agency policies were centered in the Office of the Administrator and operations were carried on through three major constituents:

The Federal Home Loan Bank Administration, which pro-

* Resigned, December 5, 1946.

vided a national credit reserve through the Federal Home Loan Bank System, insured savings through the Loan Insurance Corporation, and supervised the Home Owners' Loan Corporation;

The Federal Housing Administration, which insured home mortgages made by private financing institutions and processed all priorities for privately financed war housing;

The Federal Public Housing Authority, charged with responsibility for publicly financed war housing and the prewar low-rent slum clearance program carried out by local housing authorities.

This concentration of authority made it possible for housing to be represented in the highest wartime councils and enabled the National Housing Agency to utilize the full resources of private enterprise and Government in the task of providing adequate shelter for migrating war workers and their families.

At the conclusion of its war job, the NHA had carried out a program to provide the necessary shelter to meet the needs of over 4,000,000 migrating war workers and their families—an estimated 9,000,000 persons in all. About half of these workers were taken care of in existing structures. Housing for the others had to be built.

Construction was limited strictly to the needs created by essential migration of war workers. Whenever feasible, existing buildings were converted into additional dwelling units, thereby minimizing the use of materials, manpower and money. In new construction, drastic economies in the use of critical war materials were made and substitute materials were used whenever possible.

The NHA closely coordinated war housing programs with the War Manpower Commission, as to necessary migration of war labor; with the War Production Board, which allocated materials; with the War and Navy Departments, the Maritime Com-

mission and other supply agencies as to the housing needs of specific war industries.

In the communities, the NHA sought and secured the cooperation of local governments, business, labor and citizens generally in making maximum use of the existing housing supply. Through War Housing Centers, operated in about 170 of the most crowded war industry areas, and through local "Share-Your-Home" campaigns, approximately 2,000,000 accommodations, including over 600,000 for families, were secured from the existing housing supply.

Where additional housing was required, the NHA first programmed privately financed construction or conversion of permanent dwellings to the extent that postwar demand for the housing appeared reasonably assured and the capacity was available to produce the housing under wartime conditions. This privately financed war housing totals 1,165,955 units of which 1,063,977 units had been completed as of March 31, 1946, representing a private investment of approximately $5,585,-765,000, largely protected by FHA mortgage insurance.

Where private enterprise could not meet the need because of prohibitive wartime risks, public financing was necessary for the construction or conversion of 853,229 family dwellings, dormitory quarters or stop-gap units under appropriations and authorizations totaling approximately $2,271,176,000. More than 700,000 of these publicly financed units were administered by FPHA. Built to meet emergency needs, about two-thirds of them were either temporary or stop-gap in character to be removed after the war, or were converted from existing structures. As of March 31, 1946, all but 12,354 of the publicly financed war housing units programmed had been completed.

In all, war housing has been nearly an $8,000,000,000 job. Over $5,500,000,000 was carried by private capital and approximately $2,250,000,000 by public funds. War housing re-

quired millions of pounds of metal, billions of feet of lumber; it has required several thousand contractors and builders and the employment of tens of thousands of men and women. Like every other industry, housing had to fight for materials and labor; had to use ingenuity to produce a low cost product against the rising costs of building; had to invent and substitute and seek new methods and had to work against time.

Temporary housing was one answer to the need for economy and speed. But even the permanent housing erected with private capital was "stripped" for war. Under the H-1 program a privately constructed house could not cost more than $6,000 or rent for more than $50 per month, plus utilities.

Even where private building could be justified, builders needed help; so a new Title VI was added to the National Housing Act—and later was expanded—which gave almost complete protection by Government to the investment of private funds.

As the needs of the migrating war workers began to be met, the NHA, acting in concert with the WPB, laid plans as early as July 1944 to broaden the war housing program as rapidly as manpower and materials permitted. Supplementing the H-1 program of war housing for immigrant war workers, provision was made for two additional categories of priority housing—H-2 housing to relieve general congestion with a ceiling of $8,000 and H-3 housing to relieve cases of individual hardship and to take care of returning veterans. Thus a core of the building industry was kept active in meeting imperative needs and in preparation for the postwar job.

Disposition of war housing began soon after the end of the war with Japan. All privately financed war housing was released from war housing controls on October 15, 1945. By March 31, 1946, only 727,293 publicly financed units remained in the status of war housing. New occupancy in the permanent structures is now restricted to veterans of World War II. The

temporary and demountable accommodations are rapidly being reduced through re-use for temporary housing of veterans by colleges, universities and municipalities under the Veterans Emergency Housing Program.

TOTAL WAR HOUSING: H-1, H-2, AND H-3

ESTIMATED DEVELOPMENT COST AND TOTAL NUMBER OF ACCOMMODATIONS COMPLETED, STARTED, AND DISPOSED OF JULY 1, 1940–MARCH 31, 1946

TYPE OF PROGRAM AND TYPE OF ACCOMMODATION	Estimated Development Cost in Thousands of Dollars (Started)	Accommodations Completed	Accommodations Started	Accommodations Disposed of
Grand total—All war housing (H-1, H-2, H-3)	7,856,941	1,904,852	2,019,184	1,291,891
Privately financed, total [4]	5,585,765	1,063,977	1,165,955	1,165,955
Publicly financed, total	2,271,176	840,875	853,229	125,936
H-1: Housing for immigrant war workers, total	7,321,427	1,853,867	1,889,862	1,162,569
Privately financed, total [1]	5,050,890	1,012,992	1,036,837	1,036,837
New permanent units	4,853,270	814,402	837,691	837,691
Converted units	197,620	198,590	199,146	199,146
Publicly financed, total	2,270,537	840,875	853,025	125,732
New permanent family dwellings	909,519	193,240	195,422	47,305
Demountable family dwellings	333,290	80,159	80,159	5,941
Temporary family dwellings	756,430	268,489	276,577	22,989
Converted family dwellings, not HOLC	1,709	855	855	172
Converted family dwellings, HOLC	79,120 [2]	49,731	49,731	518
Single-person accommodations	130,626	167,960	169,017	23,046
Stop-gap accommodations	59,843	80,441	81,264	25,761
H-2: Housing to relieve general congestion, total	230,679	2,582	30,876	30,876
Privately financed family dwellings [1]	230,040	2,582	30,672	30,672
Publicly financed family dwellings	639	0	204	204
H-3: [3] Housing to relieve individual hardship, total [1]	304,835	48,403	98,446	98,446
Privately financed				
New construction family units	277,200	16,600	61,600	61,600
For veterans	64,368	3,855	14,304	14,304
For other hardship cases	212,832	12,745	47,296	47,296
Converted family dwelling units	27,635	31,803	36,846	36,846

[1] All privately financed figures are as of September 30, 1945.
[2] Subject to revision. [3] All H-3 data are estimates.
[4] Partially estimated.

National Housing Agency, Office of the Administrator, Statistics & Control Branch, Statistics Division, June 12, 1946.

6

The United States Maritime Commission

By Vice Admiral W. W. Smith, USN. (ret.)

Chairman

The United States Maritime Commission was established by the Merchant Marine Act of 1936. The Commission was directed by this legislation to replace overage and obsolescent vessels with ships in quality and number adequate for two purposes: To carry a substantial portion of United States imports and exports, and to give auxiliary service to the armed forces in times of emergency.

An orderly construction program inaugurated in 1937 to build 50 ships per year for ten years was increased because of the turbulence in Europe, to 400 per year in 1941. A basic design was developed which became the Commission's famed C-types, and they remain the standard product of the Commission.

After Pearl Harbor, the number of shipyards holding Maritime Commission contracts grew from 40 to almost 80 at the peak of the program in 1943. In 1937 there had been but ten United States shipyards capable of building ocean going vessels. At the peak of the program some 702,000 men and women were employed in merchant shipyards, 90 per cent of whom learned the mechanics of their specialized tasks in shipyard training

courses maintained through the joint efforts of shipyard management and the Maritime Commission.

Every shipbuilding record was broken in 1942 and 1943. Liberty ships were delivered in as little as 20 days, keel laying to steam in boilers. By Presidential directive the Commission was required to build 8 million deadweight tons of shipping in 1942 and twice that in 1943. The tonnage built in 1942 was 7 times that built in 1941; the 1943 tonnage total was 17 times that of 1941. The two year program of 24 million tons was exceeded by 3.3 million tons. In two years the 1.15 million tons built in 1941 had been multiplied 24 times, while the minimum of the directive was for 21 times. The United States built 79 per cent of all vessels built by the United Nations between the outbreak of the war in Europe and the end of the conflict.

The saving grace in meeting these goals was the Liberty ship. Its design was based on that of a British type which the Maritime Commission was building for Great Britain in 1940, to replace some of their losses.

By strict adherence to design, prefabrication of large sections of hull and superstructure, extensive use of welding, and maintenance of close schedules between manufacturing plant and shipyard, production of these vessels was developed to the point of Liberty shipyards becoming the assembly points for prefabricated parts flowing from some 1,200 plants scattered over the nation.

Before the end of 1943 all the shipping losses of the United Nations had been replaced, principally by Liberty ship construction, and the building of these emergency vessels was curtailed, ending in the summer of 1945 after 2,710 had been constructed.

This enabled the Commission to turn the great part of its

construction facilities to the building of Victory ships—faster turbine-propelled vessels of finer lines than the Liberty, but also adaptable to mass production—and the C-types of the original long range program. Building of tankers was also increased, and, in close cooperation with the Joint Chiefs of Staff, designs were developed for special types sorely needed for the war against Japan.

By the end of the war there had been built in United States shipyards under direction of the Maritime Commission 5,558 oceangoing vessels, whose aggregate deadweight tonnage * was 54,630,106 tons. These included Liberty ships; Victory ships; C-types; tankers, barges of wood, steel or concrete; ore carriers; harbor and oceangoing tugs; and, on the military side, aircraft carriers, frigates, transports, hospital ships, tank carriers, oilers and tenders, and special combat transport and attack ships completed by the Navy on Maritime Commission hulls. In addition, 1,200 small craft were built.

The rapidity with which the construction program was expanded is illustrated in the following table, showing the ships and tonnages delivered between the first of the long range deliveries in 1939 and September 1, 1945.

YEAR	LIBERTY SHIPS	OTHER VESSELS	TOTAL VESSELS	DWT TONNAGE *
1939	0	28	28	341,219
1940	0	54	54	638,038
1941	2	101	103	1,159,765
1942	542	218	760	8,044,527
1943	1,232	717	1,949	19,209,991
1944	720	1,066	1,786	16,299,985
1945 (to 9/1)	104	774	878	8,681,140
	2,600	2,958	5,558	54,374,674

* Deadweight tonnage is the measure of a ship's cargo carrying capacity in tons of 2,240 pounds. It is the number of tons of cargo, including ships stores and fuel, which will load the vessel to the Plimsoll line, the mark on the hull which denotes loading to the capacity for safe operation.

The shipyards were located strategically along the Atlantic, Pacific and Gulf coasts and the Great Lakes, the latter region producing vessels limited in their size by facilities for getting them to sea.

The West Coast produced most of the ships, 39.7 per cent of the total number built. There were 29.1 per cent built on the Atlantic Coast, 26.2 per cent on the Gulf and 5 per cent on the Great Lakes.

The number of principal types built to September 1, 1945, in addition to the 2,710 Liberty Ships was:

Standard Cargo—C-types, refrigerated vessels and passenger cargo ships	548
Victory ships cargo	379
Standard ocean going tankers	673
Military types—including straight military vessels and those built as or converted to military types	627
	2,227

The remainder was a miscellany of coastal vessels and types for special purposes. Total estimated expenditures of the Commission from its inception to September 1, 1945 were slightly over 14 billions of dollars, of which $634,500,000 were for facilities and for restoring facilities in shipyards used in the wartime program.

Characteristics of the principal vessel types are:

	DWT TONNAGE	LENGTH	BEAM	SPEED (KNOTS)
Liberty	10,865	441′ 6″	56′ 10″	11
Victory	10,850	455′ 3″	62′	17
C-Types	9,300 to 12,600	417′ 9″ to 492′	60′ to 69′ 6″	14 to 16½
T2-Tanker	16,500	523′ 6″	68′	14½
T3-Tanker	18,300	553′	75′	18

7

The Bureau of Reclamation

By Michael W. Straus

Commissioner

Food and power for a nation at war were the chief objectives of the Bureau of Reclamation's wartime construction. Food production on land irrigated by Reclamation projects reached its highest levels during the war years. Power plants operated by the Bureau at its great dams in the West generated nearly 14 million kilowatt-hours of electric energy in the year ending June 30, 1944. They were a major factor in the rapid expansion of Western war industry and made possible the building of great numbers of planes, tanks, and ships, and the production of huge quantities of other essential fighting equipment.

During the war years, Reclamation construction was necessarily restricted to only those projects approved by the War Production Board. Work on more than a billion dollars' worth of planned construction was either halted or deferred under WPB orders. Nevertheless, four of the largest concrete dams in the world were completed: Grand Coulee, Shasta, Friant, and Marshall Ford. Two other smaller dams also were completed —Green Mountain Dam, on the Colorado-Big Thompson project in Colorado, and Vallecito Dam on the Pine River project in Colorado.

While these gigantic works were being built, the Bureau was pressing forward and overcoming some of the difficulties of

obtaining necessary materials and manpower for construction of less spectacular, but highly important projects for irrigation and other purposes. These include nine large storage dams, major canals, and numerous other facilities of importance to their regions.

The nine dams are Keswick, in California; Wickiup, in Oregon; Altus, in Oklahoma; Anderson Ranch, in Idaho; Davis, in Arizona-Nevada; Deerfield, in South Dakota; Jackson Gulch, in Colorado; Newton, in Utah; and Scofield, also in Utah.

One of the Bureau's most dramatic accomplishments in wartime construction was the Alva B. Adams Tunnel, 13 miles long, piercing the Continental Divide between Estes Park and Grand Lake, Colorado.

Canal construction progressed during the war. The 37-mile Madera Canal, in California, was advanced. Work went forward on the Provo Reservoir Canal in Utah, to enlarge it for a distance of 22 miles. Construction also progressed on the Heart Mountain Canal in Wyoming. Work went on to enlarge the nine-mile Weber-Provo Diversion Canal in Utah.

Work also continued on the 95-mile main canal of the Yakima project in the State of Washington. An additional 27 miles of the Coachella Branch of the All-American Canal project also received approval. This canal when completed will be 145 miles long. Progress also was made on the construction of the Provo River project in Utah, including the Salt Lake City aqueduct.

Construction was completed during the war on two projects on the Water Conservation and Utilization Program. Work on six other projects that had been authorized before the war was allowed to continue. Six more projects were authorized after the war began, and construction on them was pushed forward.

The projects completed were: Buffalo Rapids No. 1, in Montana, and Budford-Trenton, in North Dakota. The six projects

on which work was continued were: The Mirage Flats, in Nebraska; Buffalo Rapids No. 2, in Montana; Newton, in Utah; Rapid Valley, in South Dakota; Mancos, in Colorado; Scofield, also in Utah. The projects which were authorized during the war included the following four in Montana: Intake, Missoula Valley, Milk River (Dodson Unit), Bitterroot (Woodside Unit); and the Rathdrum Prairie (Post Falls Unit) in Idaho, and Balmorhea in Texas.

The Bureau's wartime construction program was a definite contribution to the victory, both in connection with irrigation, which is Reclamation's primary peacetime objective, and in connection with hydro power generated as a concomitant feature of the irrigation projects. Around Reclamation projects in the far Western States, grew up the factories and plants that produced ships, planes, and bombs, and the aluminum, the magnesium, the steel and copper that were used for those weapons. More than 90 per cent of the new power that was produced by war-created Bureau facilities was transmitted to war industries.

The Government invested approximately half a billion dollars in war plants and military posts near Bureau developments. One of these was the world's largest basic magnesium plant. Five aluminum plants and an aluminum rolling mill, valued at $130,000,000 were built. An additional $200,000,000 was invested in the expansion of the airplane industry. Military establishments—none costing probably less than $10,000,000—were erected near Bureau projects.

Bureau plants powered about one-third of the national output of pig aluminum, the biggest carbide plant west of the Mississippi, metallurgical plants, major shipyards, synthetic rubber plants, important air bases, and other military encampments. All the way down the list, Bureau projects were enlisted for the war. Power output expanded from 976,675 kilowatts,

the total rated capacity of Bureau power plants on July 1, 1941, to 2,357,775 kilowatts.

Along with its efforts to provide the electric energy to keep pace with the demand, the Bureau also concentrated on the other point in its war program—expansion of food production to meet the enlarged wartime food requirements. Enough beans were produced on the millions of acres of land irrigated by Reclamation projects to provide yearly rations for 54 million persons; enough potatoes for more than 30 millions. Alfalfa and grain produced on federally irrigated land, fed to beef and dairy herds, produced milk rations for 4,800,000 persons, and beef for 5¼ million persons. The average annual production of essential food from Reclamation project land during the war years exceeded 10½ million tons.

The war was the acid test of the essentiality of the Reclamation program to the strength and development of the Nation.

8

The Public Roads Administration

By Thomas H. MacDonald
Commissioner

Meeting the needs of highway transport for war purposes was the only objective of the Public Roads Administration during the war years. Immediately after the declaration of war in December, 1941, approval of highway projects was restricted to roadbuilding activities certified by the War and Navy Departments as essential to the war effort. Later the War Production Board was included as a certifying agency.

One of the most important phases of the roadbuilding program during the war years was the removal of highway bottlenecks at military and naval establishments, munitions plants and shipyards. Another important activity was the construction of access roads to sources of urgently needed raw materials such as coal, iron, copper and manganese mines and hardwood forests. Correction of critical deficiencies in main highways over which industrial workers traveled to and from war plants and convoys of trucks laden with troops or war materials rolled on their way to Atlantic and Pacific seaports was also a necessity.

Construction of access roads on a large scale began shortly after passage of the Defense Highway Act of November 19, 1941, which authorized an appropriation of $150,000,000 to build access roads to military and naval reservations, to defense

industries and to sources of war materials. An amendment of this act on July 2, 1942, provided an additional $110,000,000. The funds were made available to pay the full cost of improvements, including right-of-way, but it was the policy of the Public Roads Administration to seek local participation to the extent of important local benefits. On April 4, 1944, access road funds authorized by the Defense Highway Act as amended were increased from $260,000,000 to $290,000,000 with a provision that a sum not exceeding $5,000,000 might be used for the improvement and maintenance of roads in maneuver areas certified by appropriate war agencies.

Roads designed to accommodate large volumes of traffic were a primary requirement in the development of aircraft factories, munitions plants and other war industries. At the beginning of the war, workers at plants in operation were sometimes delayed one and two hours in reporting for work because of traffic jams. Instances were reported where portions of plant shifts actually gave up trying to reach the plant and went home. Traffic congestion slowed both traffic and industrial production. This condition was corrected by replacing narrow roads with broad highways over which industrial workers could travel swiftly between their homes and jobs.

The construction of access roads to hundreds of war industries, army camps and naval bases overshadowed all other road work during the war years but a limited amount of work also was done on main highways used in transporting war materials and the necessities of life for war workers. Keeping principal highways in serviceable condition for the heavy traffic generated by wartime activities was just as necessary as the construction of access roads.

Federal-aid funds made available in prewar years were expended for improvements on 12,936 miles of highway in 1941,

including all types of road work, and improvements on 10,178 miles of highway in 1942. By the end of the fiscal year 1945, road-building activities had declined to improvements on 4,011 miles of highway of all classes. Highways completed during the fiscal year consisted of 3,302 miles of access road, 462 miles of the strategic network and 247 miles of miscellaneous construction of war significance.

As of April 30, 1946, the defense highway program had resulted in the completion of improvements of 18,755 miles of highway at a total cost of $650,645,088. The projects included 11,782 miles of access roads costing $317,076,651; 6,506 miles on the strategic network at a cost of $307,852,231; and 486 miles of miscellaneous work costing $25,716,206. A total of 273 grade crossings were eliminated, and 381 grade crossings were protected by signals and other safety devices. The total Federal contribution amounted to $505,061,642.

Nearly $5,000,000 of access road funds were expended in constructing roads in Washington State, Tennessee and New Mexico in connection with the production of atomic bombs.

Another important wartime activity was the program of flight-strip construction authorized by the Defense Highway Act of 1941. This program was completed during the fiscal year 1944, when 12 flight strips were placed in service, bringing the total number to 26. In the latter part of August, 1943, the War Department presented an emergency request for three more flight strips, to be built in the shortest time possible. These were completed in record time.

In the summer and fall of 1942 engineer troops and forces of civilian contractors working on the Alaska Highway under the direction of the Public Roads Administration succeeded in forcing through a pioneer road from Dawson Creek, in British Columbia, to a junction with the Richardson Highway near

Fairbanks, Alaska. Work on the all-year truck route was resumed by civilian forces in the spring of 1943. The work crews of 81 contractors, employing 14,000 civilian workers and using 6,000 heavy units of road-building equipment, working two shifts of 10 hours each day, completed the grading and gravel surfacing by the end of October.

DEFENSE HIGHWAY PROJECTS COMPLETED AS OF APRIL 30, 1946

	TOTAL COST	FEDERAL FUNDS	MILES	RAILROAD GRADE CROSSINGS Elimi-nated	RAILROAD GRADE CROSSINGS Pro-tected
Strategic network roads	$307,852,231	$205,080,427	6,506.3	151	148
Access Roads	317,076,651	281,806,426	11,782.5	116	198
Other approved projects	25,716,206	18,174,789	486.2	6	35
Total	$650,645,088	$505,061,642	18,775.0	273	381

9

The Petroleum Administration for War

By Ralph K. Davies

Deputy Petroleum Administrator

The production of 100-octane gasoline was one of the outstanding construction and industrial achievements of the war. Compared with 87-octane fuel, standard when the war began, 100-octane gasoline cuts take-off distance of planes 16 per cent, increases ceiling 27 per cent, climbing speed 40 per cent, and carrying capacity 43 per cent.

One-sixth less take-off meant much in carrier based operations and in quick utilization of captured fields. Seven tons of bombs instead of five meant much in blasting Tokyo. Increased climb and ceiling often meant life itself to a fighter pilot. On all counts, 100-octane gasoline was the lifeblood of the United Nations in the air.

In May 1941 there were 16 plants in the United States equipped to make 100-octane; four in the rest of the allied and neutral world. Their combined daily capacity was about 44,000 barrels.

Foreseeing the need for many times this amount, the Petroleum Administration for War launched a far-flung program embracing both a more effective use of existing facilities and new plant construction.

The construction stage of this program required placing 100,000 orders with more than 500 different manufacturers. PAW kept in close touch with construction, checked the engineering, and helped with manpower problems.

Toward the end of 1945 there were 73 100-octane plants in the United States, 10 in allied countries, 4 under construction in Russia, and more were being built when V-J Day came. Some 400 other refineries and natural gasoline plants in the United States contributed base stock, components, or in other ways forwarded the program.

Each year's output more than doubled that of the preceding year. Output for 1944 was greater than all preceding years together. Output for March 1945 was 525,000 barrels a day in the United States and more than 600,000 barrels by the United Nations excluding Russia, an increase of 1,265 per cent over the world's total capacity in May 1941.

Considerably more than $927,000,000 was spent for major refinery projects in this country during the war, exclusive of plants for toluene for explosives, and butadiene for synthetic rubber. That sum is based on preliminary estimates, not final costs which usually proved to be substantially higher than original estimates, and does not include many minor projects which could be undertaken without special authorization. The actual total for refinery construction probably ran well above $1,000,000,000.

Of that total, more than $864,000,000 went for facilities for producing 100-octane gasoline, about 75 per cent of which was spent for facilities owned and operated by the industry and 25 per cent for plants built by the Government and leased to the industry.

In addition to the construction of plants, the entire oil transportation pattern of the country had to be revamped, a revamp-

ing that affected the delivery of oil products to virtually every city and hamlet in the country. Comparable changes were required in the pattern of all ocean and overseas transportation.

Because of an over-all tanker shortage, it was necessary to move the maximum volume of Trans-Atlantic oil supplies overland to the East Coast in order to save tanker time to Europe and Africa. A new overland transportation pattern, therefore, had to be developed to move more of both civilian and overseas supplies into coastal districts.

Tank cars, normally used for short-haul distribution of refined products, were pressed into long-distance service, running in mile-long trains on through-express schedules. The distribution of products formerly done by tank cars was switched to tank trucks. Every available truck that could haul oil products was put to use, most of them 24 hours a day 7 days a week. Every available tank barge was put in service on the inland waterways and intracoastal channels, many additional barges and tugs were built, and barge-loading facilities were greatly enlarged and extended. A gigantic pipe-line program was carried through, including the two largest and longest permanent lines ever built. The pipe lines built, relaid, and reversed would reach from New York to Yokohama via the sea route through Suez and Singapore.

The expenditure for pipe line construction during the war totaled more than $300 million, much of it financed by Government due to its emergency nature. Largest project, both from the point of view of cost and effect on the war program, was "Big Inch," the 24-inch line built at a cost of $79 million from Longview, Texas, to Phoenixville Junction, Pennsylvania, a distance of 1,254 miles. "Big Inch" had a crude oil capacity of 300,000 barrels a day and by the end of 1943, a few months after its

completion, was transporting approximately half of the crude brought into the East Coast area.

The next largest pipe line construction job was "Little Inch," a 1,475-mile line from Beaumont, Texas, to Linden, New Jersey, costing approximately $68.5 million. Constructed of 20-inch pipe, this line carried petroleum products such as gasoline and fuel oil, about two-thirds of which were for military and one-third for essential civilian uses.

Four other government-financed pipe lines cost about $14.8 million bringing the cost for the six projects totaling 3,833 miles in length to approximately $162.3 million. In addition, 34 other important pipe line projects in various parts of the country were built, relocated, reversed or converted from natural gas to oil service by private industry at a cost at least as great as the government-financed lines. Final cost figures for these private industry projects are not available but an estimate by the Petroleum Industry War Council, industry advisory group to the PAW, sets the total at $192 million, and mileage at 13,851.

PAW was also active in sponsoring large-scale construction of other types of transportation facilities, including hundreds of ocean-going tankers, railroad tank cars, barges and motive power for river and inland waterway shipment of petroleum. Other agencies of Government also were involved in connection with these construction programs. In addition, PAW had responsibility for construction of natural gasoline plants, natural-gas pipe lines, access roads to oil and gas properties, secondary recovery and gas repressuring projects, bulk plants and terminals, essential service stations and essential housing.

10

The Civil Aeronautics Administration

By Theodore P. Wright

Administrator

Construction work performed directly under Civil Aeronautics Administration auspices during the war was very heavy, involving more than $364,000,000 in expenditures.

Another important CAA contribution to wartime construction, though not directly measurable in dollars, was the participation of CAA technical experts in the world-wide construction of air navigation facilities such as radio ranges and communications stations.

Finally, there should be taken into account the CAA Technical Development Service's perfection of new methods and devices which speeded up construction of airports in combat areas.

As recently as 1939 there was not a single Class 4 or 5 airport in the entire country, that is, large fields capable of accommodating military aircraft of all types. In 1940 Congress set out to remedy the situation with an appropriation to CAA for the construction of airports under the Defense Landing Area Program. More appropriations were made as the work progressed and the need for additional landing fields became apparent, until at the close of the war a total of almost $400,000,000 had been allocated and a total of 563 large airports

constructed, developed or enlarged. Many were leased to the Army and Navy.

Working in close cooperation with the Army and Navy, contracts for the construction of these fields were let out to private contractors in all but a very few cases.

At the same time contracts were let out for completion of 26 Development of Civilian Landing Area (former WPA) projects. The cost involved for these projects totaled $9,718,719 but was part of the $400,000,000 figure mentioned.

The program was restricted to grading, drainage, paving of runways and installation of field lighting. No buildings were constructed. In addition to the airfields newly built for the services, many existing airports were enlarged and turned over for use by the military.

Construction of airfields was not confined to the limits of continental United States. A total of 29 projects were completed under CAA direction in Alaska, Hawaii, Canton Island, Palmyra Island, Panama Canal Zone, Puerto Rico, and in the South Pacific area. Total funds expended for the projects were $31,191,374.

Just prior to the United States' entry into hostilities a confidential plan for installation of aids to air navigation, including airports, seaplane bases, radio ranges and weather stations was made by CAA engineers and specialists. It covered the Pacific and the West Indies areas. This document dated July, 1941, was entitled "Confidential Report of National Defense Projects."

CAA experts later participated in carrying out many of the recommendations of this plan, and in the development of airway facilities for the Army and Navy in other parts of the world.

In August, 1942, for example, CAA was called upon by the Army to assist in the establishment of their airways communica-

DEPARTMENT OF COMMERCE, CIVIL AERONAUTICS ADMINISTRATION, OFFICE OF AIRPORTS

CAA Airport Construction under the Defense Landing Areas and Development of Civilian Landing Areas Program as of May 1, 1946

STATE LOCATION	NO. OF LOCATIONS	FUNDS DLA	FUNDS DCLA	CONSTRUCTION COSTS	ADMINISTRATION	TOTAL
CONTINENTAL UNITED STATES						
Alabama	12	12	–	$ 6,034,041.33	$ 221,049.24	$ 6,255,090.57
Arizona	12	12	–	5,004,497.39	239,430.82	5,243,928.21
Arkansas	5	5	–	4,436,467.64	201,505.82	4,637,973.46
California	39	39	1	21,092,084.91	759,988.39	21,852,073.30
Colorado	3	3	1	805,684.19	26,913.57	832,597.76
Connecticut	7	6	1	1,833,097.49	74,317.80	1,907,415.29
Delaware	3	3	–	2,445,546.60	119,936.04	2,565,482.64
Dist. of Columbia	2	2	–	1,407,120.13	64,924.29	1,472,044.42
Florida	42	42	–	30,976,034.95	979,716.57	31,955,751.52
Georgia	27	26	1	13,125,697.04	559,799.19	13,685,496.23
Idaho	8	8	1	2,785,272.24	132,822.14	2,918,094.38
Illinois	5	5	–	6,406,343.44	319,500.00	6,725,843.44
Indiana	7	6	1	4,634,870.48	224,234.18	4,859,104.66
Iowa	7	5	2	6,480,569.27	331,607.22	6,812,176.49
Kansas	6	5	1	2,132,699.82	72,761.79	2,205,461.61
Kentucky	6	6	–	4,863,201.55	229,321.66	5,092,523.21
Louisiana	15	14	1	10,879,035.78	545,360.88	11,424,396.66
Maine	22	21	1	7,483,413.86	249,359.67	7,732,773.53
Maryland	5	5	–	4,486,473.00	201,628.62	4,688,101.62
Massachusetts	11	10	1	6,979,551.64	301,739.43	7,281,291.07
Michigan	7	6	1	6,266,920.95	203,973.78	6,470,894.73
Minnesota	6	3	3	3,466,705.28	198,456.76	3,665,162.04
Mississippi	10	10	–	4,600,662.95	210,944.81	4,811,607.76
Missouri	4	4	–	4,056,393.90	194,609.46	4,251,003.36
Montana	12	12	–	3,764,252.73	157,539.01	3,921,791.74
Nebraska	5	3	2	3,011,216.39	98,967.54	3,110,183.93
Nevada	7	6	1	3,762,699.89	94,581.99	3,857,281.88
New Hampshire	7	7	–	3,132,800.24	139,444.82	3,272,245.06
New Jersey	7	7	–	8,441,500.38	366,878.64	8,808,379.02

New Mexico	10	9	1	$ 4,445,788.48	$ 220,311.93	$ 4,666,100.41
New York	21	21	–	19,854,878.57	948,459.78	20,803,338.35
North Carolina	18	16	2	9,349,807.13	347,233.40	9,697,040.53
North Dakota	8	7	1	5,026,139.69	240,776.96	5,266,916.65
Ohio	7	7	–	7,810,023.87	362,384.80	8,172,408.67
Oklahoma	15	14	1	11,489,236.65	442,124.15	11,931,360.80
Oregon	21	21	–	13,302,967.53	584,149.49	13,887,117.02
Pennsylvania	8	8	–	14,217,396.10	664,055.78	14,881,451.88
Rhode Island	2	2	–	612,650.94	13,333.31	625,984.25
South Carolina	14	14	–	8,861,915.68	404,755.08	9,266,670.76
South Dakota	2	2	–	581,918.48	27,345.32	609,263.80
Tennessee	5	5	–	5,104,173.53	172,021.37	5,276,194.90
Texas	40	39	1	25,498,072.80	1,144,452.59	26,642,525.39
Utah	6	6	–	2,914,338.30	133,013.59	3,047,351.89
Vermont	4	4	–	2,312,680.90	91,660.94	2,404,341.84
Virginia	10	10	–	9,456,809.88	358,344.93	9,815,154.81
Washington	17	17	–	11,719,547.88	541,883.33	12,261,431.21
West Virginia	6	5	1	5,290,361.04	268,043.05	5,558,404.09
Wisconsin	6	3	3	3,035,241.66	173,360.00	3,208,601.66
Wyoming	5	5	1	3.819.734.34	123.898.19	3,943,632.53
Total—Continental United States	534	508	30 [1]	$349,498,538.91	$14,782,922.12	$364,281,461.03
OUTSIDE OF CONTINENTAL UNITED STATES						
Alaska	14	14	–			
Canton Island	1	1	–	20,279,714.71	951,011.00	21,230,725.71
Hawaii	8	8	–	1,250,000.00	0	1,250,000.00
Palmyra Isle	1	1	–	5,906,419.29	51,271.61	5,957,690.90
Panama Canal	1	1	–	385,200.00	0	385,200.00
Puerto Rico	1	1	–	58,979.13	0	58,979.13
Samoa	1	1	–	14,230.00	0	14,230.00
South Pacific	2	2	–	900,000.00	0	900,000.00
Total Outside of Continental United				1,394,548.45	0	1,394,548.45
States	29	29	–	$ 30,189,091.58	$ 1,002,282.61	$ 31,191,374.19
GRAND TOTAL	563	537 [2]	30	$379,687,630.49	$15,785,204.73	$395,472,835.22

[1] Four locations have both DLA and DCLA funds. Total DCLA Funds to date $9,718,719.00.
[2] Two locations have no .001 limitations (construction funds).

tions, weather reporting stations and air navigation facilities on the ferry route to Great Britain. CAA assigned many civil and radio engineers to remote projects in Canada, Labrador, Greenland, Iceland and the United Kingdom.

As the war fronts broadened, CAA technicians also helped in the establishment of facilities across the South Atlantic, Africa, and India, and down through the Pacific to Australia.

CAA made several important contributions in airport research. In June, 1943 a report was prepared by CAA experts on the utilization of resin for soil stabilization in the Pacific and African theaters of war.

The development of a mechanical cement spreader was completed in March, 1943, and was quickly adopted by the Army. At the same time research was progressing on the effects of weather on airport soils and paving.

In addition a special study was initiated dealing with "Determination of Engineering Characteristics of Airport Soils Through the Aid of Aerial Photographs." Although engineers showed considerable skepticism at the time, the results of the projects proved to be of inestimable value to our Air Forces at a later date.

11

The Federal Works Agency

By Major General Philip B. Fleming

Administrator

War-swollen communities, with the aid of the Federal Works Agency, during and immediately before the war, built schools, hospitals, water and sewerage works, recreational facilities and other community facilities costing nearly half a billion dollars. Located in every State and in most of the Territories and bases, these public works contributed to the health, safety and well being of workers and service men and women whom the needs of war had shifted to industrial communities or military establishments far from their homes.

The FWA allotted $456,012,708 of Lanham Act funds for the construction of 4,066 projects with a total estimated cost of $456,012,462. Of these, 3,922 projects had been substantially or wholly completed by March 31, 1946, at an estimated cost of $390,965,700 of which $318,476,616 was made up of Federal grants and loans and the remainder of applicants' funds. The remaining 144 projects which were under construction on V-J Day have not yet been completed, and some of these have been discontinued.

Schools led in number of wholly or substantially completed projects—1,192—and in expenditure of Federal funds, $79,252,087. Hospital projects, of which 822 had been wholly or substantially completed at the end of the first quarter of 1946,

led in total estimated cost, $98,139,243 as against $93,417,492 for schools, and were second in expenditure of Federal funds, $77,490,571.

Recreational facilities were third in number of projects, 720, but fifth in total cost and in expenditure of Federal funds. Water works projects, of which there were 439 costing an estimated $90,046,712, and sewerage projects, of which there were 432 costing an estimated $31,400,036, were third and fourth, respectively, in total cost and in expenditure of Federal funds.

California led the States in the number of projects, with 423, and Texas was second with 354 projects. All but 14 of the California projects, and all but 10 of those in Texas, have been completed.

Largely because of some very large water supply and sewerage projects in the vital Hampton Roads area, Virginia, with only 233 projects, led in the total estimated cost of its projects and in the amount of Federal funds expended. The estimated cost of the Virginia projects was $48,094,969, of which Federal funds were allotted in the amount of $41,292,841. All but 10 of these projects had been completed by March 31, 1946, at a total estimated cost of $41,330,543, of which Federal funds made up $35,850,359.

In carrying out the wartime construction program, FWA architects and engineers were forced to draw on all their ingenuity. It was necessary to use substitutes from the beginning; in many instances, it became necessary to find substitutes for substitutes. Yet the resulting structures were safe, substantial and functionally adequate.

Because elevators early became unobtainable, hospitals of masonry construction were limited to two stories in height, and were equipped with ramps. The materials which were most plentiful locally were specified. In some instances, this meant

that one-story frame structures had to be erected; in others, brick, stone or concrete was available. During the latter part of the war, lumber and lumber products became critically short, so that they could be used only for purposes directly connected with the war. Pre-cast units, gypsum, asbestos and cement sheathing, steel, masonry and other products took the place of construction lumber. The building program, therefore, assumed a greater degree of permanency and economic value, minus architectural embellishment and many conventional features, the absence of which does not affect the utility or safety of the resulting structures.

Community facilities to the value of $164,661,660 had been completed by March 31, 1946, as Federal projects in communities unable, or unwilling, to contribute any part of the cost. Title to these projects will remain in the Federal Government until such time as they can be sold or otherwise disposed of in the best public interest.

The bulk of the construction completed by that date, however, had been done under contracts awarded by local authorities. The total estimated cost of $226,304,040 was made up of $72,489,084 of applicants' funds, $147,361,465 of Federal grants and $6,453,491 of Federal loans.

In general, contracts were let after competitive bidding. In a few instances, when the need for the facility was too urgent to permit advertising for bids, contracts were negotiated on a cost-plus-a-fixed-fee basis.

It is interesting to note that $1,632,144 of Lanham Act funds were spent for the construction of schools, sewer and water works, hospitals, health centers, recreation buildings and other community facilities to serve the workers in Tennessee and Washington State who were engaged in development and manufacture of the atomic bomb.

APPENDIX

A: Statistics

B: Chronology of War Production

TABLE

TOTAL VALUE OF FACILITIES PUT IN PLACE DURING DESIGNATED PERIODS, BY

MILLIONS OF DOLLARS

UCT OR SERVICE	TOTAL	1940 3RD QTR.	1940 4TH QTR.	1941 1ST QTR.	1941 2ND QTR.	1941 3RD QTR.	1941 4TH QTR.
TOTAL	$76,065	$3,156	$3,250	$3,471	$4,350	$5,123	$4,917
FACTURING 3/	25,233	487	584	807	1,128	1,319	1,496
RCRAFT, ENGINES, PARTS & ACCESSORIES	3,763	31	50	91	147	193	200
IP CONSTRUCTION & REPAIR	2,552	8	17	52	80	152	135
MBAT & OTHER MOTORIZED VEHICLES	866	36	42	46	49	25	30
NS & AMMUNITION	2,365	10	21	46	90	159	245
PLOSIVES & AMMUNITION LOADING	2,719	5	25	97	186	163	231
ON & STEEL, BASIC & SEMI-FINISHED	2,398	69	74	87	127	137	147
NFERROUS METALS, BASIC & SEMI-FINISHED......	1,511	20	26	31	46	57	54
CHINE TOOLS & OTHER METAL WORKING EQUIPMENT.	328	13	14	17	21	17	20
CHINERY & ELECTRICAL EQUIPMENT & APPLIANCES.	969	22	25	29	34	36	46
NTHETIC RUBBER............................	761	1	1	1	2	4	5
IATION GASOLINE...........................	899	A	A	1	2	5	9
HER CHEMICALS, COAL & PETROLEUM PRODUCTS....	1,905	82	88	95	110	117	101
OD PROCESSING.............................	983	60	62	61	65	72	80
HER MANUFACTURING.........................	2,837	122	131	144	159	172	181
DISTRIBUTED 4/............................	377	8	8	9	10	10	12
STRIAL SERVICE	9,236	524	542	432	541	610	724
S, LIGHT, HEAT & POWER.....................	3,120	249	201	113	196	253	274
ANSPORTATION & COMMUNICATION...............	6,116	275	341	319	345	357	450
OLEUM EXTRACTION & MINING	3,404	168	143	163	200	225	199
CULTURE 5/	7,538	450	287	371	545	572	291
-INDUSTRIAL SERVICE	17,810	1,440	1,430	1,193	1,564	1,891	1,558
GHWAYS, ROADS & STREETS.....................	3,122	270	264	208	269	330	285
USING 6/..................................	9,983	770	795	667	931	1,123	866
HER NON-INDUSTRIAL.........................	4,705	400	371	318	364	438	407
TARY	12,844	87	264	505	372	506	649
NTINENTAL UNITED STATES	11,021	43	216	449	319	441	571
WAR DEPARTMENT.............................	7,580	31	175	394	237	337	443
NAVY DEPARTMENT............................	3,441	12	41	55	82	104	128
N-CONTINENTAL	1,823	44	48	56	53	65	78
WAR DEPARTMENT.............................	909	12	15	20	29	20	23
NAVY DEPARTMENT............................	914	32	33	36	24	45	55

[1] Unduplicated total of federally financed projects, projects for which applications for authority to construct (Forms WPB–617 and WPB–2774) have been approved and projects for which applications for necessity certificates have been approved. Where these sources did not fully reflect activity for a period, data obtained from other sources were used.

ONE

TYPE OF PRODUCT OR SERVICE, THIRD QUARTER 1940—SECOND QUARTER 1945[1]

MILLIONS OF DOLLARS

1942				1943				1944				1
1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.
$4,459	$5,894	$6,512	$5,437	$4,354	$4,193	$3,713	$3,020	$2,417	$2,398	$2,684	$2,197	$2,08
1,590	1,972	2,470	2,403	1,996	1,821	1,313	1,146	865	725	904	720	70
242	227	315	420	346	345	231	209	145	113	219	94	9
191	291	381	297	209	202	130	118	84	51	63	28	1
39	83	98	96	57	41	29	21	16	25	31	28	3
234	245	277	244	145	106	82	44	40	32	61	65	10
254	284	477	323	196	133	61	37	24	8	27	51	4
112	169	190	220	219	225	171	149	94	60	44	38	3
93	167	173	181	181	157	93	94	44	37	29	10	
23	38	43	36	25	26	12	9	3	2	2	3	
56	78	88	86	79	63	59	59	45	39	40	32	2
8	23	45	85	155	158	114	71	28	16	11	13	
17	38	60	87	90	98	104	102	89	66	42	36	2
100	120	137	146	130	116	89	80	64	52	65	59	6
56	47	43	43	41	37	32	35	35	39	43	45	4
153	144	128	123	107	93	82	90	125	152	189	188	16
12	14	14	14	16	20	24	28	29	33	38	30	2
560	619	501	439	361	430	397	399	407	350	391	360	31
189	252	181	182	139	146	99	114	150	107	115	52	5
371	367	320	257	222	284	298	285	257	243	276	308	26
165	127	135	133	133	151	156	172	168	197	205	185	18
252	403	451	232	196	336	419	265	311	455	502	332	39
1,153	1,365	832	678	624	551	617	520	404	425	448	387	28
144	174	218	134	75	105	145	85	57	80	100	73	4
660	910	391	381	412	283	302	302	247	227	206	174	11
349	281	223	163	137	163	170	133	100	118	142	140	13
739	1,408	2,123	1,552	1,044	904	811	518	262	246	234	213	20
620	1,241	1,949	1,384	906	751	576	331	212	207	220	202	19
458	970	1,547	959	521	474	366	198	97	82	83	57	5
162	271	402	425	385	277	210	133	115	125	137	145	13
119	167	174	168	138	153	235	187	50	39	14	11	1
38	58	72	55	48	101	169	161	39	23	7	6	
81	109	102	113	90	52	66	26	11	16	7	5	

Civilian Production Adm

[2] Preliminary
[3] Excludes Manhattan Engineer District Project.
[4] Projects costing less than $25,000, for manufacturing groups except food processing and other manufacturing
[5] Sources: Department of Agriculture estimate and WPB
[6] Source: Bureau of Labor Statistics
A Less than $500,000

TABLE

CONSTRUCTION VALUE OF FACILITIES PUT IN PLACE DURING DESIGNATED PERIODS,

MILLIONS OF DOLLARS

...CT OR SERVICE	TOTAL	1940 3RD QTR.	1940 4TH QTR.	1941 1ST QTR.	1941 2ND QTR.	1941 3RD QTR.	1941 4TH QTR.
TOTAL	$49,067	$2,224	$2,260	$2,362	$2,963	$3,663	$3,409
...CTURING 3/	10,158	173	220	347	523	617	746
...CRAFT, ENGINES, PARTS & ACCESSORIES........	1,508	9	19	44	69	89	88
... CONSTRUCTION & REPAIR......................	1,524	6	12	34	54	102	95
...AT & OTHER MOTORIZED VEHICLES.............	182	12	14	12	6	3	3
... & AMMUNITION...............................	834	6	10	16	43	68	125
...LOSIVES & AMMUNITION LOADING	1,885	4	20	73	149	124	191
... & STEEL, BASIC & SEMI-FINISHED...........	728	11	12	17	30	33	43
...ERROUS METALS, BASIC & SEMI-FINISHED......	655	13	15	19	32	35	28
...INE TOOLS & OTHER METAL WORKING EQUIPMENT.	91	4	5	7	6	4	6
...INERY & ELECTRICAL EQUIPMENT & APPLIANCES.	272	5	7	8	10	11	15
...HETIC RUBBER................................	217	A	A	A	A	1	2
...TION GASOLINE...............................	107	A	A	A	A	A	1
...R CHEMICALS, COAL & PETROLEUM PRODUCTS....	717	38	35	40	44	56	50
... PROCESSING.................................	339	20	22	21	22	25	28
...R MANUFACTURING.............................	940	42	46	52	54	62	66
...STRIBUTED 4/................................	159	3	3	4	4	4	5
...RIAL SERVICE	3,520	174	183	165	192	214	247
..., LIGHT, HEAT & POWER.......................	1,275	71	75	71	78	87	108
...SPORTATION & COMMUNICATION................	2,245	103	108	94	114	127	139
...LEUM EXTRACTION & MINING	1,729	94	77	81	97	113	102
...ULTURE 5/	3,006	256	86	71	215	322	107
...NDUSTRIAL SERVICE	17,810	1,440	1,430	1,193	1,564	1,891	1,558
...WAYS, ROADS & STREETS.......................	3,122	270	264	208	269	330	285
...SING 6/.....................................	9,983	770	795	667	931	1,123	866
...R NON-INDUSTRIAL............................	4,705	400	371	318	364	438	407
...ARY	12,844	87	264	505	372	506	649
...TINENTAL UNITED STATES	11,021	43	216	449	319	441	571
...AR DEPARTMENT................................	7,580	31	175	394	237	337	443
...AVY DEPARTMENT...............................	3,441	12	41	55	82	104	128
...-CONTINENTAL	1,823	44	48	56	53	65	78
...AR DEPARTMENT................................	909	12	15	20	29	20	23
...AVY DEPARTMENT...............................	914	32	33	36	24	45	55

[1] Unduplicated totals of federally financed projects, projects for which applications for authority to construct (Forms WPB-617 and WPB-2774) have been approved and projects for which applications for necessity certificates have been approved. Where these sources did not fully reflect activity for a period, data obtained from other sources were used. Construction totals include land.

[2] Preliminary

[3] Excludes Manhattan Engineer District Project.

TWO

BY TYPE OF PRODUCT OR SERVICE, THIRD QUARTER 1940—SECOND QUARTER 1941 [1]

MILLIONS OF DOLLARS

1942				1943				1944				
1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.
2,969	$4,120	$4,715	$3,618	$2,670	$2,510	$2,358	$1,714	$1,215	$1,310	$1,475	$1,174	$1,02
726	893	1,197	1,044	718	620	423	345	269	226	277	258	25
100	103	176	238	154	121	81	48	44	33	32	22	2
124	192	242	158	108	106	62	65	48	24	33	14	1
9	21	34	31	10	5	3	2	2	3	4	4	
83	91	82	60	32	22	25	10	14	9	19	25	4
199	194	338	222	102	69	23	19	10	4	19	39	2
26	58	69	79	70	72	60	42	25	23	17	14	1
43	71	71	75	61	66	37	33	11	14	12	4	
9	14	12	8	4	4	1	1	1	1	1	1	
19	28	30	22	16	13	13	13	12	11	11	11	1
3	11	23	29	39	39	29	22	5	3	5	3	
3	5	4	9	8	7	10	12	11	11	9	6	
28	29	51	50	59	45	30	26	22	15	26	26	2
20	17	15	14	14	13	12	12	12	13	15	17	1
55	53	44	43	35	30	27	29	40	49	61	64	4
5	6	6	5	6	8	10	11	12	13	13	8	1
205	209	215	182	158	178	160	154	138	157	175	144	12
89	90	80	60	56	51	40	33	43	55	66	39	3
116	119	135	122	102	127	120	121	95	102	109	105	8
85	62	72	69	65	75	76	85	81	99	106	94	9
61	183	276	93	61	182	271	92	61	157	235	78	5
1,153	1,365	832	678	624	551	617	520	404	425	448	387	28
144	174	218	134	75	105	145	85	57	80	100	73	4
660	910	391	381	412	283	302	302	247	227	206	174	11
349	281	223	163	137	163	170	133	100	118	142	140	13
739	1,408	2,123	1,552	1,044	904	811	518	262	246	234	213	20
620	1,241	1,949	1,384	906	751	576	331	212	207	220	202	19
458	970	1,547	959	521	474	366	198	97	82	83	57	5
162	271	402	425	385	277	210	133	115	125	137	145	13
119	167	174	168	138	153	235	187	50	39	14	11	1
38	58	72	55	48	101	169	161	39	23	7	6	
81	109	102	113	90	52	66	26	11	16	7	5	

Civilian Production Admini

[4] Projects costing less than $25,000, for manufacturing groups except food processing and other manufacturing

[5] Source: Department of Agriculture estimate. Includes maintenance and repair. A breakout of new construction is under consideration by the Department.

[6] Source: Bureau of Labor Statistics. Includes new construction, additions, alterations, and the minor proportion of repairs included in building permits.

A Less than $500,000

TABLE

CONSTRUCTION VALUE OF FEDERALLY FINANCED FACILITIES PUT IN PLACE DURING DESIG-

MILLIONS OF DOLLARS

T OR SERVICE	TOTAL	1940 3RD QTR.	1940 4TH QTR.	1941 1ST QTR.	1941 2ND QTR.	1941 3RD QTR.	1941 4TH QTR.
TOTAL	$23,486	$187	$474	$806	$865	$1,103	$1,286
CTURING 3/	7,198	15	51	164	324	388	521
RAFT, ENGINES, PARTS & ACCESSORIES	1,329	1	8	32	57	78	77
CONSTRUCTION & REPAIR......................	1,447	4	9	32	52	96	89
BAT & OTHER MOTORIZED VEHICLES............	93	1	1	2	1	A	1
S & AMMUNITION	718	3	8	12	37	60	115
LOSIVES & AMMUNITION LOADING	1,878	3	20	73	149	123	191
& STEEL, BASIC & SEMI-FINISHED............	472	A	A	2	10	5	17
FERROUS METALS, BASIC & SEMI-FINISHED......	505	3	3	3	7	8	9
HINE TOOLS & OTHER METAL WORKING EQUIPMENT.	30	A	A	A	2	A	1
HINERY & ELECTRICAL EQUIPMENT & APPLIANCES.	96	–	1	A	1	2	5
THETIC RUBBER..............................	192	–	–	–	–	A	1
ATION GASOLINE.............................	27	–	–	–	–	–	–
ER CHEMICALS, COAL & PETROLEUM PRODUCTS....	313	–	A	3	6	10	7
PROCESSING.................................	8	–	–	–	–	–	A
ER MANUFACTURING...........................	90	A	3	4	2	6	8
TRIAL SERVICE	333	–	A	A	A	4	6
, LIGHT, HEAT & POWER......................	136	–	A	A	A	4	6
NSPORTATION & COMMUNICATION................	197	–	–	–	–	–	A
LEUM EXTRACTION & MINING	63	–	–	–	A	–	1
NDUSTRIAL SERVICE 3/	3,048	85	159	137	169	205	109
HIGHWAYS...................................	632	5	14	15	32	50	25
SING.......................................	2,341	80	145	122	137	155	82
ING SCHOOLS................................	75	–	–	–	–	–	2
ARY	12,844	87	264	505	372	506	649
TINENTAL UNITED STATES	11,021	43	216	449	319	441	571
AR DEPARTMENT..............................	7,580	31	175	394	237	337	443
AVY DEPARTMENT.............................	3,441	12	41	55	82	104	128
-CONTINENTAL	1,823	44	48	56	53	65	78
AR DEPARTMENT..............................	909	12	15	20	29	20	23
AVY DEPARTMENT.............................	914	32	53	36	24	45	55

[1] Includes projects financed by the War Department, Navy Department, Maritime Commission, Defense Plant Corporation, Reconstruction Finance Corporation, Defense Supplies Corporation, Department of Interior, Department of Agriculture, Tennessee Valley Authority, and the British Ministry of Supply Mission.

THREE

NATED PERIODS, BY TYPE OF PRODUCT OR SERVICE, THIRD QUARTER 1940—SECOND QUARTE

MILLIONS OF DOLLARS

1942				1943				1944				
1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1S QT
1,499	$2,609	$3,435	$2,749	$1,984	$1,652	$1,343	$951	$491	$431	$453	$387	$36
559	744	1,054	921	601	521	324	238	149	102	128	115	12
90	92	166	228	145	112	72	39	36	26	25	16	2
119	186	235	161	103	101	58	62	46	21	29	12	
7	17	29	17	9	3	1	A	A	1	A	A	
71	81	69	51	23	18	21	8	12	7	16	22	4
198	193	337	222	101	69	23	19	9	4	19	39	2
12	45	57	69	59	65	53	31	16	14	7	4	
34	70	70	75	65	64	36	29	7	11	8	1	
1	8	2	5	2	2	A	A	A	–	A	A	
7	15	18	12	8	6	4	3	2	3	4	2	
2	5	15	26	37	39	28	21	4	3	5	3	
–	A	A	2	2	2	3	4	4	4	2	2	
10	19	43	44	42	36	20	17	11	6	11	10	
A	1	A	1	A	1	1	1	A	A	A	2	
8	12	6	8	5	3	4	4	2	2	2	2	
11	16	24	40	33	56	40	33	12	22	29	2	
10	16	13	10	10	7	2	1	7	18	26	1	
1	A	11	30	23	49	38	32	5	4	3	1	
1	2	7	6	6	9	7	15	2	3	1	1	
189	438	227	230	300	162	161	147	66	58	61	56	2
19	41	74	44	32	50	69	47	13	21	32	19	1
160	382	147	182	262	100	82	94	50	36	29	37	1
10	15	6	4	6	12	10	6	3	1	–	–	
739	1,408	2,123	1,552	1,044	904	811	528	262	246	234	213	20
620	1,241	1,949	1,384	906	751	576	331	212	207	220	202	19
458	970	1,547	959	521	474	366	198	97	82	83	57	5
162	271	402	425	385	277	210	133	115	125	137	145	13
119	167	174	168	138	153	235	187	50	39	14	11	1
38	58	72	55	48	101	169	161	39	23	7	6	
81	109	102	113	90	52	66	26	11	16	7	5	

Civilian Production Admini

[2] Excludes Manhattan Engineer District Project.

[3] Excludes federally financed non-industrial facilities expansion (other than war highways, public housing, and flying schools) not segregated by source of funds.

A Less than $500,000

UCTION VALUE OF NON-FEDERALLY FINANCED FACILITIES PUT IN PLACE DURING DESIGNATED

MILLIONS OF DOLLARS

R SERVICE	TOTAL	1940 3RD QTR.	1940 4TH QTR.	1941 1ST QTR.	1941 2ND QTR.	1941 3RD QTR.	1941 4TH QTR.
TOTAL	$25,581	$2,037	$1,786	$1,556	$2,098	$2,560	$2,12
IPING	2,900	158	169	183	199	229	22
T, ENGINES, PARTS & ACCESSORIES	179	8	11	12	12	11	1
NSTRUCTION & REPAIR..................	77	2	3	2	2	6	
& OTHER MOTORIZED VEHICLES............	89	11	13	10	5	3	2
AMMUNITION...........................	116	3	4	4	6	8	1
VES & AMMUNITION LOADING..............	7	1	A	A	A	1	
STEEL, BASIC & SEMI-FINISHED..........	256	11	12	15	20	28	2
ROUS METALS, BASIC & SEMI-FINISHED	150	10	12	16	25	27	1
TOOLS & OTHER METAL WORKING EQUIPMENT.	61	4	5	6	4	4	
RY & ELECTRICAL EQUIPMENT & APPLIANCES.	176	5	6	8	9	9	1
IC RUBBER............................	25	A	A	A	A	1	
N GASOLINE...........................	20	A	A	A	A	A	
HEMICALS, COAL & PETROLEUM PRODUCTS....	404	38	35	37	38	46	4
OCESSING.............................	331	20	22	21	22	25	2
ANUFACTURING.........................	850	42	43	48	52	56	5
IBUTED 3/............................	159	3	3	4	4	4	
L SERVICE	3,187	174	183	165	192	210	24
GHT, HEAT & POWER....................	1,139	71	75	71	78	83	10
RTATION & COMMUNICATION..............	2,048	103	108	94	114	127	13
EXTRACTION & MINING	1,666	94	77	81	97	113	10
RE 4/	3,006	256	86	71	215	322	10
STRIAL SERVICE	14,762	1,355	1,271	1,056	1,395	1,686	1,4
S, ROADS & STREETS...................	2,490	265	250	193	237	280	26
5/...................................	7,642	690	650	545	794	968	78
ON-INDUSTRIAL 6/.....................	4,630	400	371	318	364	438	40

[1] Unduplicated total of non-federally financed projects for which applications for authority to construct (Forms WPB-617 and WPB-2774) have been approved and projects for which applications for necessity certificates have been approved. Where these sources did not fully reflect activity for a period, data obtained from other sources were used. Data do not include projects financed by Reconstruction Finance Corporation or Defense Supplies Corporation, where legal title is or may be privately held.

[2] Preliminary

[3] Projects costing less than $25,000, for manufacturing groups except food processing and other manufacturing

FOUR

PERIODS, BY TYPE OF PRODUCT OR SERVICE, THIRD QUARTER 1940—SECOND QUARTER

MILLIONS OF DOLLARS

1942				1943				1944				1945 [2]	
1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.	3RD QTR.	4TH QTR.	1ST QTR.	2ND QTR.
$1,470	$1,511	$1,280	$860	$686	$858	$1,015	$763	$724	$879	$1,022	$787	$654	$903
167	149	147	123	117	99	99	107	120	124	149	143	124	133
10	11	10	10	9	9	9	9	8	7	7	6	5	4
5	6	6	7	5	5	4	3	2	3	4	2	2	2
2	4	5	4	1	2	2	2	2	2	4	4	4	7
12	10	13	9	9	4	4	2	2	2	3	3	4	4
1	[illegible]	1	A	1	A	A	A	1	A	A	A	A	A
14	17	12	10	12	7	7	11	9	9	10	10	10	11
9	1	1	A	4	2	1	4	4	3	4	3	3	2
8	6	4	3	2	2	1	1	1	1	1	1	1	1
12	13	12	10	8	7	[illegible]	10	10	8	7	9	8	6
1	6	8	3	2	A	1	1	1	A	A	A	A	A
3	5	4	7	6	5	7	8	7	7	7	4	4	5
18	10	8	6	8	9	10	9	11	9	15	16	18	20
20	15	15	13	14	12	11	11	12	13	15	15	13	13
47	41	38	35	31	27	23	25	38	47	59	62	40	38
5	6	6	6	6	8	10	11	12	13	13	8	12	20
194	193	191	142	125	122	120	121	126	135	146	142	124	141
79	74	67	50	46	44	38	32	36	37	40	38	35	43
115	119	124	92	79	78	82	89	90	98	106	104	89	98
84	59	65	63	59	66	69	70	70	96	105	93	91	104
61	163	276	93	61	152	271	92	61	157	235	78	57	142
964	921	605	448	324	389	456	373	338	361	387	331	258	383
125	133	144	90	43	55	76	38	44	59	68	54	31	45
500	528	244	199	150	183	220	208	197	192	177	137	97	180
339	266	217	159	131	151	160	127	97	117	142	140	130	158

Civilian Production Administration

[4] Source: Department of Agriculture estimate. Includes maintenance and repair. A breakout of new construction is under consideration by the Department.

[5] Source: Bureau of Labor Statistics. Includes new construction, additions, alterations, and the minor proportion of repairs included in building permits.

[6] Includes federally financed non-industrial facilities expansion (other than war highways, public housing, and flying schools) not segregated by source of funds.

A Less than $500,000

TABLE

EQUIPMENT VALUE OF FACILITIES PUT IN PLACE DURING DESIGNATED PERIODS,

MILLIONS OF DOLLARS

CT OR SERVICE	TOTAL	1940 3RD QTR.	1940 4TH QTR.	1941 1ST QTR.	1941 2ND QTR.	1941 3RD QTR.	1941 4TH QTR.
TOTAL	$26,998	$932	$990	$1,109	$1,387	$1,460	$1,508
ACTURING 3/	15,075	314	364	460	605	702	750
RAFT, ENGINES, PARTS & ACCESSORIES........	2,255	22	31	47	78	104	112
CONSTRUCTION & REPAIR	1,028	2	5	18	26	50	40
AT & OTHER MOTORIZED VEHICLES	684	24	28	34	43	22	27
S & AMMUNITION..............................	1,531	4	11	30	47	91	120
LOSIVES & AMMUNITION LOADING	834	1	5	24	37	39	40
N & STEEL, BASIC & SEMI-FINISHED..........	1,670	58	62	70	97	104	104
FERROUS METALS, BASIC & SEMI-FINISHED......	856	7	11	12	14	22	26
HINE TOOLS & OTHER METAL WORKING EQUIPMENT.	237	9	9	10	15	13	14
HINERY & ELECTRICAL EQUIPMENT & APPLIANCES.	697	17	18	21	24	25	31
HETIC RUBBER..............................	544	1	1	1	2	3	3
TION GASOLINE..............................	792	A	A	1	2	5	8
ER CHEMICALS, COAL & PETROLEUM PRODUCTS....	1,188	44	53	55	66	61	51
D PROCESSING................................	644	40	40	40	43	47	52
ER MANUFACTURING...........................	1,897	80	85	92	105	110	115
ISTRIBUTED 4/..............................	218	5	5	5	6	6	7
TRIAL SERVICE	5,716	350	359	267	349	396	477
, LIGHT, HEAT & POWER......................	1,845	178	126	42	118	166	166
NSPORTATION & COMMUNICATION...............	3,871	172	233	225	231	230	311
LEUM EXTRACTION & MINING	1,675	74	66	82	103	112	97
ULTURE 5/	4,532	194	201	300	330	250	184

1 Unduplicated totals of federally financed projects, projects for which applications for authority to construct (Forms WPB-617 and WPB-2774) have been approved and projects for which applications for necessary certificates have been approved. Where these sources did not fully reflect actively for a period, data obtained from other sources were used. 2 Preliminary

FIVE

BY TYPE OF PRODUCT OR SERVICE, THIRD QUARTER 1940—SECOND QUARTER 1945

MILLIONS OF DOLLARS

1942 1st Qtr.	1942 2nd Qtr.	1942 3rd Qtr.	1942 4th Qtr.	1943 1st Qtr.	1943 2nd Qtr.	1943 3rd Qtr.	1943 4th Qtr.	1944 1st Qtr.	1944 2nd Qtr.	1944 3rd Qtr.	1944 4th Qtr.
$1,490	$1,774	$1,797	$1,819	$1,684	$1,653	$1,355	$1,306	$1,202	$1,088	$1,209	$1,023
864	1,079	1,273	1,359	1,278	1,201	890	801	596	499	627	462
142	124	140	182	192	225	150	161	101	80	187	72
67	99	139	131	101	96	68	53	36	27	30	14
30	62	64	75	47	36	26	19	14	22	27	24
151	154	195	184	113	84	57	34	26	23	42	40
55	94	139	101	94	64	38	18	14	4	8	12
86	111	121	141	149	153	111	107	69	37	27	24
50	96	102	106	112	91	56	61	33	23	17	6
14	24	31	28	21	22	11	8	2	1	1	2
37	50	58	54	63	50	46	46	33	28	29	21
5	12	22	56	116	119	85	49	23	13	6	10
14	33	56	78	82	91	94	90	78	55	33	30
72	91	86	96	80	71	59	54	42	37	39	33
36	30	28	29	27	24	20	23	23	•26	28	28
98	91	84	80	71	63	55	61	85	103	128	124
7	8	8	8	10	12	14	17	17	20	25	22
355	410	286	257	203	252	237	245	269	193	216	216
100	162	101	122	83	95	59	81	107	52	49	13
255	248	185	135	120	157	178	164	162	141	167	203
80	65	63	64	67	75	80	87	87	98	99	91
191	220	175	139	135	154	148	173	250	298	247	254

Civilian Production Ad

[3] Excludes Manhattan Engineer District Project.

[4] Projects costing less than $25,000 for manufacturing groups except food processing and other manufacturing

[5] Sources: Department of Agriculture estimate and WPB

A Less than $500,000

TABLE

NEW PRIVATE CONSTRUCTION IN THE CON-

MILLIONS OF DOLLARS

Item	1915	1916	1917	1918	1919	1920
Total private	2,220	2,753	2,869	2,486	3,775	4,785
Residential (excl. farm)[1]	950	1,066	902	691	1,536	1,545
Nonresidential building[2]	513	771	860	771	1,147	2,082
Industrial[3]	[4]	[4]	[4]	[4]	[4]	1,099
Commercial[3]	[4]	[4]	[4]	[4]	[4]	625
Religious	[4]	[4]	[4]	[4]	[4]	55
Educational	[4]	[4]	[4]	[4]	[4]	22
Social & recreational	[4]	[4]	[4]	[4]	[4]	104
Hospital & institutional	[4]	[4]	[4]	[4]	[4]	30
Hotels	[4]	[4]	[4]	[4]	[4]	118
Miscellaneous nonresidential building	[4]	[4]	[4]	[4]	[4]	29
Farm	205	255	315	323	414	381
Public utility	552	661	792	701	678	777
Railroad	241	281	361	365	266	184
Street railway	112	109	154	107	63	82
Pipe line	20	20	20	24	56	41
Electric light & power	95	120	127	106	161	268
Gas	41	70	45	26	56	73
Telephone	35	53	74	58	64	109
Telegraph	8	8	11	15	12	15

[1] Estimates of new private non-farm residential construction prepared by the Bureau of Labor Statistics for 1920–1929.

[2] Excludes nonresidential building by privately-owned public utilities.

SIX

TINENTAL UNITED STATES, 1915–1929

MILLIONS OF DOLLARS

1921	1922	1923	1924	1925	1926	1927	1928	1929
3,998	5,385	7,006	7,715	8,451	9,066	8,762	8,339	7,522
1,661	2,734	3,640	4,195	4,505	4,496	4,175	3,569	2,797
1,543	1,638	1,896	1,897	2,373	2,878	2,825	2,797	2,822
574	467	549	460	513	727	696	802	949
570	613	716	740	940	1,107	1,145	1,121	1,097
71	103	117	130	165	177	179	168	139
32	61	83	91	108	108	106	107	113
119	132	128	131	199	255	252	224	164
44	53	57	63	79	83	105	100	98
109	181	199	222	313	365	291	224	199
24	28	47	60	56	56	50	51	63
183	218	270	257	259	251	283	275	279
611	795	1,200	1,366	1,314	1,441	1,479	1,393	1,624
184	176	361	365	393	491	462	433	520
59	85	74	56	52	51	77	90	82
30	41	53	70	55	36	80	53	97
170	237	421	473	433	388	391	364	396
66	139	133	206	171	248	257	212	135
90	107	143	177	192	206	196	227	328
12	10	15	19	18	21	16	19	26

U.S. Department of Commerce

[3] Public industrial and commercial building not segregable from private construction.

[4] Not available.

TABLE

NEW PUBLIC CONSTRUCTION IN THE CON-

MILLIONS OF DOLLARS

Item	1915	1916	1917	1918	1919	1920
Total public	715	703	1,273	2,231	1,963	1,334
Residential	-	-	-	28	14	-
Nonresidential building	217	207	192	199	246	283
Public administration	1/	1/	1/	1/	1/	38
Educational	1/	1/	1/	1/	1/	190
Social & recreational	1/	1/	1/	1/	1/	12
Hospital & institutional	1/	1/	1/	1/	1/	33
Miscellaneous	1/	1/	1/	1/	1/	10
Military and naval	17	21	608	1,555	1,089	161
Highways	298	308	313	288	415	640
State	165	168	174	180	256	432
County	2/	2/	2/	2/	2/	2/
Municipal	133	140	139	108	159	208
Sewage disposal & water supply	106	95	91	94	124	153
Sewage disposal	52	46	45	38	53	67
Water supply	54	49	46	56	71	86
Miscellaneous public service enterprises	40	43	41	37	35	41
Conservation & development	36	28	27	29	39	55
Bureau of Reclamation	7	6	6	6	5	5
Army Engineers	27	20	18	20	29	41
Other construction and development	2	2	3	3	5	9
All other Federal	1	1	1	1	1	1

[1] Not available.

SEVEN

TINENTAL UNITED STATES, 1915–1929

MILLIONS OF DOLLARS

1921	1922	1923	1924	1925	1926	1927	1928	1929
1,550	1,657	1,598	1,862	2,108	2,113	2,368	2,462	2,391
-	-	-	-	-	-	-	-	(
387	481	481	494	573	603	596	638	622
51	55	44	39	56	70	84	85	103
274	342	346	353	400	399	367	378	367
14	15	20	22	37	47	48	50	36
40	60	55	60	61	68	80	108	95
8	9	16	20	19	19	17	17	21
49	25	16	9	8	11	12	15	19
840	851	783	951	1,056	1,039	1,190	1,270	1,248
281	286	284	384	396	363	416	511	529
337	330	242	256	265	266	289	282	257
222	235	257	311	395	410	485	477	462
178	201	203	263	278	285	312	300	253
78	88	90	108	133	145	174	183	127
100	113	113	155	145	140	138	117	126
43	49	48	65	119	112	192	157	150
52	48	65	79	73	61	63	72	86
7	9	9	8	7	6	6	7	8
36	30	43	55	51	41	40	46	59
9	9	13	16	15	14	17	19	19
1	2	2	1	1	2	3	10	13

U.S. Department of Commerce

[2] Included in state.

TABLE

NEW PRIVATE CONSTRUCTION IN THE CON-

MILLIONS OF DOLLARS

Item	1929	1930	1931	1932	1933	1934	1935
Total private 1/	7,522	5,306	3,416	1,482	1,005	1,221	1,648
Residential (excl. farm) 2/	2,797	1,446	1,228	462	278	361	665
Nonresidential building 3/	2,822	2,099	1,104	499	404	455	472
Industrial 4/	949	532	221	74	176	191	158
Warehouses, office, and loft buildings 4/	581	559	259	110	41	62	70
Stores, restaurants, and garages 4/	516	297	178	106	86	107	136
Religious	139	128	82	43	20	20	26
Educational	113	112	94	50	14	13	16
Social and recreational	164	140	116	57	32	32	32
Hospital and institutional	98	103	67	32	9	8	10
Hotels	199	164	46	15	8	8	11
Miscellaneous nonresidential building	63	64	41	12	18	14	13
Farm Construction	279	193	97	39	69	93	176
Residential	147	107	59	26	43	54	96
Nonresidential	132	86	38	13	26	39	80
Public utility construction	1,624	1,568	987	482	254	312	335
Railroad	510	521	292	139	94	128	116
Street railway	82	85	69	29	21	30	40
Pipe line	97	30	77	37	7	12	20
Electric light and power	396	418	266	124	52	52	59
Gas	185	181	117	66	35	43	48
Telephone	328	310	154	80	41	43	48
Telegraph	26	23	12	7	4	4	4

[1] Estimates for 1944 and 1945 are joint estimates of the Department of Commerce and the Department of Labor.

[2] Estimates of new private non-farm residential construction prepared by the Bureau of Labor Statistics

EIGHT

TINENTAL UNITED STATES, 1929–1945

MILLIONS OF DOLLARS

1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
2,486	3,274	2,941	3,619	4,199	5,238	2,908	1,669	1,746	2,547
1,131	1,372	1,511	2,114	2,355	2,765	1,315	650	535	670
712	1,088	764	785	1,028	1,486	635	232	350	1,014
266	492	232	254	442	801	346	156	208	642
104	128	89	76	85	114	57	13	16	52
179	250	190	211	257	286	93	19	39	147
32	42	48	46	56	59	29	5	11	26
37	40	38	37	47	55	23	6	10	28
51	69	92	94	63	68	28	6	16	24
16	30	33	29	31	44	27	11	25	34
15	22	19	17	23	27	14	2	4	11
12	15	23	21	24	32	18	14	21	50
189	225	196	226	236	303	271	292	213	191
104	118	104	120	127	174	144	185	136	116
85	107	92	106	109	129	127	107	77	75
454	589	470	494	580	684	687	495	648	672
149	199	119	137	167	187	197	211	247	264
45	39	41	54	50	30	12	14	15	20
41	67	21	35	30	60	80	77	71	50
75	102	132	114	120	117	156	69	86	102
77	80	65	61	91	111	87	63	146	119
62	96	87	89	117	173	150	56	78	112
5	6	5	4	5	6	5	5	5	5

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[3] Excludes nonresidential building by privately-owned public utilities.

[4] Public industrial and commercial building not segregable from private construction in 1929–1932

TABLE

NEW PUBLIC CONSTRUCTION IN THE CON-

MILLIONS OF DOLLARS

Item	1929	1930	1931	1932	1933	1934	1935
otal public 1/	2,391	2,753	2,564	1,778	1,218	1,535	1,368
Residential	-	-	-	-	-	1	9
Nonresidential building	622	623	578	392	193	256	179
Industrial	2/	2/	2/	2/	2	11	2
Commercial	2/	2/	2/	2/	4	13	7
Public administration	103	121	173	173	89	44	74
Educational	367	344	269	123	43	110	36
Social and recreational	36	26	18	15	6	27	19
Hospital and institutional	95	111	104	78	43	41	31
Miscellaneous nonresidential building	21	21	14	3	6	10	10
Military and naval	19	29	40	34	36	47	37
Highways	1,248	1,481	1,323	916	675	821	622
State	529	678	694	524	424	544	412
County	257	297	278	183	136	163	111
Municipal	462	506	351	209	115	114	99
Sewage disposal and water supply	253	343	270	156	81	116	137
Sewage disposal	127	142	114	69	34	54	68
Water supply	126	201	156	87	47	62	69
Miscellaneous public service enterprises	150	157	209	135	61	41	59
Conservation and development	86	111	135	139	168	245	317
Bureau of Reclamation	8	11	20	26	26	35	47
Army Engineers	59	75	81	81	102	142	177
Tennessee Valley Authority	-	-	-	-	5	17	28
Other conservation and development	19	25	34	32	35	51	65
All other Federal	13	9	9	6	4	8	8
Pipe line	-	-	-	-	-	-	-
All other Federal	13	9	9	6	4	8	8

[1] Estimates for 1944 and 1945 are joint estimates of the Department of Commerce and the Department of Labor.

NINE

TINENTAL UNITED STATES, 1929–1945

MILLIONS OF DOLLARS

1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
2,228	2,034	2,077	2,441	2,739	5,346	10,656	6,218	2,451	2,050
61	93	35	76	205	479	600	685	190	71
597	459	556	792	497	1,667	3,742	2,111	879	822
4	2	12	18	144	1,400	3,571	2,006	748	640
14	22	18	30	33	24	9	2	4	4
130	110	127	171	98	52	30	10	11	15
323	221	266	399	130	131	86	36	41	59
50	34	37	45	17	16	9	6	7	9
63	62	83	109	55	29	29	45	58	85
13	8	13	20	20	15	8	6	10	10
29	37	62	119	510	1,756	5,060	2,423	720	562
876	850	837	869	896	836	664	454	360	302
601	557	521	490	547	538	412	280	215	180
150	139	130	171	165	162	144	114	94	79
125	154	186	208	184	136	108	60	51	43
208	174	179	162	194	168	139	102	79	97
115	95	89	82	67	48	39	32	26	37
93	79	90	80	127	120	100	70	53	60
111	101	94	91	90	63	36	43	46	55
339	310	299	318	325	350	360	270	163	130
56	60	67	83	86	83	65	50	36	39
192	176	157	156	163	159	149	134	73	63
32	30	31	32	38	82	129	76	45	18
59	44	44	47	38	26	17	10	9	10
7	10	15	14	22	27	55	130	14	11
-	-	-	-	-	-	34	118	4	-
7	10	15	14	22	27	21	12	10	11

U.S. Department of Commerce

[2] Public commercial and industrial building not segregable from private construction in 1929–1932

TABLE TEN

NEW CONSTRUCTION ACTIVITY IN CONTINENTAL UNITED STATES, 1915–1945

MILLIONS OF DOLLARS

Year	Total	Residential (Private and Public)	All Other (Private and Public)
1915	2,935	950	1,985
1916	3,456	1,066	2,390
1917	4,142	902	3,240
1918	4,717	719	3,998
1919	5,738	1,550	4,188
1920	6,119	1,545	4,574
1921	5,548	1,661	3,887
1922	7,042	2,734	4,308
1923	8,604	3,640	4,964
1924	9,577	4,195	5,382
1925	10,559	4,505	6,054
1926	11,179	4,496	6,683
1927	11,130	4,175	6,955
1928	10,801	3,869	6,932
1929	9,913	2,797	7,116
1930	8,059	1,446	6,613
1931	5,980	1,228	4,752
1932	3,260	462	2,798
1933	2,223	278	1,945
1934	2,756	362	2,394
1935	3,016	674	2,342
1936	4,714	1,192	3,522
1937	5,308	1,465	3,843
1938	5,018	1,546	3,472
1939	6,060	2,190	3,870
1940	6,938	2,560	4,378
1941	10.584	3,244	7,340
1942	13,564	1,915	11,649
1943	7,887	1,335	6,552
1944	4,197	725	3,472
1945	4,597	741	3,856

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CHRONOLOGY OF GOVERNMENT ACTIONS AFFECTING WAR CONSTRUCTION *

1939

Sept. *1* *Germany invades Poland without a Declaration of War.*

8 President declares a Limited National Emergency. Army authorized to recruit to full statutory strength of 242,000.

War and Navy Departments issue "Industrial Mobilization Plan—Revision of 1939"—

1940

May *10* *Germany invades Belgium and the Netherlands.*

Winston Churchill succeeds Neville Chamberlain as British Prime Minister.

16 President's Defense Message sets goal of 50,000 war planes and requests $896 million more for Defense.

29 Advisory Commission to the Council of National Defense appointed by the President.

31 President requests first supplemental defense appropriation of $1.3 billion.

June *14* 11% naval expansion approved.

22 *France signs an Armistice with Germany.*

* Arranged from data in Miscellaneous Publication No. 1 of the Civilian Production Administration, Bureau of Demobilization, and Report No. 19 of The War Production Board.

June *26* First Supplemental National Defense Appropriation Act, 1941, approved for $1.3 billion.

28 Act to expedite the National Defense authorizes priority for Army and Navy Contracts, advance payment up to 30% on defense contracts, and negotiation of contracts in lieu of competitive bidding.

July *10* Two-Ocean Navy, Land Force of 1,200,000 with 800,000 Reserves, and 19,000 more war planes recommended in Presidential Message. Tax amortization and Excess Profits Legislation also urged.

18 Charles F. Palmer appointed Coordinator of Defense Housing.

19 Two-Ocean Navy Act authorizes $4 billion for 70% fleet expansion.

29 William H. Harrison appointed Director of the Construction Section of National Defense Advisory Commission.

Aug. 8 *Germany launches first heavy air attack on British Isles, beginning the battle of Britain.*

22 Defense Plant Corporation formed by Reconstruction Finance Corporation.

23 National Defense Advisory Commission announces a plan for an Emergency Plant Facilities Contract.

The President allocates $10,000,000 from his Emergency Fund to the Reconstruction Finance Corporation for defense housing purposes.

28 First program list issued by Coordinator of Defense Housing.

Sept. *2* United States arranges transfer of 50 destroyers to Britain in exchange for military bases.

6 National Defense Advisory Commission establishes principles governing the letting of national defense contracts and labor requirements for national defense orders.

9 Second Supplemental Defense Appropriation Act, 1941, increases authorized program by $5.4 billion and approves time and a half for overtime on defense contracts.

Sept. *12* Army and Navy Appropriation Bill passes Congress: $100,000,000 allocated for defense housing by the Army and Navy.

16 Selective Training and Service Act approved with provision for commandeering plants not cooperating on defense orders. Authorized strength of Army increased to 1.4 million.

24 Public Resolution 99 approved—provides funds for housing conscripts.

26 The President approves requests of War Department, Navy Department, and Maritime Commission for allocations totaling $95,340,000 for defense housing.

Oct. *4* Lanham Defense Housing Act signed by the President appropriating $150,000,000 for defense housing purposes.

Navy Department awards first contract for construction of 400 dwelling units at Long Beach, California, and 1,200 dwelling units at San Diego, California.

8 Third Supplemental Defense Appropriation Act, 1941, approved for $1.7 billion, making a total of over $12 billion appropriated for defense in current fiscal year.

Second Revenue Act of 1940 authorizes special amortization of defense facilities and other changes in Excess Profits Tax Law to encourage defense plant construction and production of munitions.

21 Priorities Board established by executive order; Donald M. Nelson named Administrator of Priorities.

Nov. *18* $7.6 Billion in defense contracts reported placed as of October 31.

Dec. *29* President's "Arsenal of Democracy" speech proposes lending arms to Britain and the democracies.

1941

Jan. *7* Office of Production Management established by President, absorbing production, purchasing, and priorities functions of Defense Advisory Commission.

11 Division of Defense Housing Coordination established.

Feb. *6* Construction of 200 Liberty ships authorized by Congress.

Mar. *1* Congress appropriates $5,000,000 to provide temporary dwelling units.

11 Lend-Lease Act approved.

27 *Britain leases military bases to United States in Western Hemisphere.*

Apr. *6* *Germany invades Yugoslavia and Greece.*

22 Authorized strength of Navy increased to 232,000 tons—300,000 in an emergency.

29 Original appropriation of Lanham Defense Housing Act increased by $150,000,000.

May *6* Plant Site Board established in Office of Production Management.

13 Office of Production Management issues policy statement on subcontracting.

27 President declares a State of Unlimited National Emergency.

June *4* Office of Price Administration Civilian Supply issues first "Civilian Allocation Program" to restrict nondefense uses of iron and steel. Other programs follow.

22 *Germany invades Soviet Russia.*

July *1* Construction value of facilities put in place amounts to $9.9 billion.

22 A Stabilization Agreement is signed between certain Government agencies engaged in defense construction and the Building and Construction Trades Department of the American Federation of Labor.

Aug. *9* Steel placed under full priority by Order M-21.

18 Congress extends military service of inductees another 18 months and calls retired Army personnel to active duty.

28 Supply Priorities and Allocations Board established.

Sept. *19* Donald M. Nelson, Director of Priorities, announces a plan for priority assistance for privately financed defense housing projects.

27 First Liberty ship launched.

Oct. *9* Supply Priorities and Allocations Board prohibits non-essential public or private construction.

28 Office of Lend-Lease Administration formally established. $6 billion additional appropriated.

Dec. *7* *Japanese attack Pearl Harbor.*

8 *The United States declares war on Japan.*

11 *Germany and Italy declare war on United States.*

18 First War Powers Act gives President Emergency Authority to create and reorganize executive agencies, make defense contracts, and control trade.

23 Industry-Labor Conference adopts No Strike Pledge and endorses Government arbitration of disputes.

1942

Jan. *1* Value of facilities put in place reaches $17 billion. Thirty-four per cent of war construction job completed.

Jan. *6* Production goals for 1942 set by President, 60,000 planes, 43,000 tanks, 20,000 anti-aircraft guns, and 8 million tons of shipping.

7 President reports total previous defense appropriations of $7.5 billion and expenditures of $51 billion.

16 War Production Board established and Supply Priorities and Allocations Board abolished by Executive Order. Donald M. Nelson, War Production Board Chairman.

26 Combined Raw Materials Board established.

27 *Churchill announces plan for combined Chiefs of Staff of Britain and the United States.*

30 Emergency Price Control Act approved.

Feb. *7* Further naval appropriation of $24 billion approved.

15 *Singapore captured by Japanese.*

Feb. 24 National Housing Agency established—housing functions consolidated thereunder.

27–28 *Japanese Navy victorious in Battle of Java Sea—Speedy conquest of Java follows.*

Mar. 5 $30 billion appropriated for Army, Maritime Commission and Lend-Lease.

8 *Japanese landing at Salamaua, New Guinea, threatens Australia.*

10 War Production Board grants priorities for construction of 200,000 additional private dwelling units.

17 War Production Board issues policy statement on construction known as the "Knowlson Resolution."

23 Relationships between War Production Board and War Department formalized by bilateral statements signed by Chairman of War Production Board and Under Secretary of War.

27 Second War Powers Act approved, with further provision for seizure of property, enforcement of priorities and rationing.

28 Another $19 billion, appropriated for Army and Navy.

Apr. 9 *Fall of Bataan.*

9 Limitation Order L-41 halts all construction not essential to public health and safety.

18 War Manpower Commission established under Paul V. McNutt.

22 Relationships between War Production Board and Navy Department formalized by bilateral statements signed by Chairman of War Production Board and Under Secretary of the Navy.

May 7 *Battle of Coral Sea halts Japanese penetration toward Australia.*

8 W.P.B. Bureau of Construction established under direction of W. V. Kahler.

11 Nelson appoints a Committee on Facilities and Construction under Chairmanship of W. H. Harrison.

20 Directive for Wartime Construction issued.

23 Limitation Order L-41-a issued.

June 3–6		*Japanese Fleet repulsed decisively at Battle of Midway.*
	11	Smaller War Plants Corporation established by Congress, responsible to Chairman of War Production Board.
	25	U.S. Army Headquarters for European Theater established in London under General Eisenhower.
July	*1*	Value of facilities put in place totals $24.1 billion.
	22	$43 billion appropriated for the Army.
	23	Amendment 2 to Limitation Order L-41 issued.
Aug.	*7*	*Marines land on Guadalcanal as U.S. goes on the offensive in South Pacific.*
Sept.	*2*	Limitation Order L-41 again amended.
	21	Joint Directive issued by Chairman of the War Production Board, Under Secretaries of War and the Navy, and Chairman of the Maritime Commission establishing a Facility Clearance Board.
Oct.	*14*	Secretary of War Stimson reports 4.25 million men in Army; 7.5 million goal for end of 1943.
	17	W.P.B. Facility Clearance Board and Facility Review Committee established.
	20	Nelson notifies heads of eight Government agencies that priority assistance to a large part of nonmilitary construction for the Federal Government will be revoked.
	23	*Battle of Egypt begins at El Alamein. German retreat to Tunisia follows its conclusion on November 3.*
	29	War Production Board uprates facilities for producing aviation gasoline to AA-2X. Aluminum expansion program also given AA-2X rating.
Nov.	*2*	Controlled Materials Plan announced for distribution of steel, copper and aluminum.
	7	*American Troops land in North Africa.*

Dec. *15* War Production Board and National Housing Agency issue jointly a new policy statement on war housing.

31 Program Determination 236 issued to expedite construction for critical programs.

1943

Jan. *1* Value of facilities put in place mounts to $32 billion. Sixty-six per cent of war construction job completed.

6 President submits war budget exceeding $100 billion for fiscal year 1944.

7 President describes 1943 production goals as double those of 1942; reports 1942 production of 48,000 military planes and 56,000 tanks.

Feb. *6* Lt. General Eisenhower named supreme commander of Allied forces in North Africa.

9 Minimum work-week of 48 hours ordered by President.

13 Office of War Utilities established.

Apr. *1* Beginning of first quarter of industry operations under Controlled Materials Plan.

10 Public debt limit raised from $125 billion to $210 billion.

May *12* *Unconditional surrender of Axis Forces in Tunisia. Campaign produced 300,000 Axis killed or captured.*

26 Funds approved for one million ton landing craft program.

Army announces savings of nearly two billion dollars through renegotiation of contracts.

27 Office of War Mobilization established under James F. Byrnes to develop "Unified Programs" and "Harmonize Government Activities." Fred M. Vinson heads Office of Economic Stabilization.

June *Allied losses from German submarines decline sharply for third consecutive month, signaling a victory in battle of the Atlantic.*

17 Appropriation made for one million more tons of naval auxiliary and amphibious craft.

June *26* Navy receives $27.4 billion appropriation for 1944.

26 Nelson announces Steel Production Drive in last six months of 1943 to overcome 20 per cent deficiency.

July *1* Value of facilities put in place amounts to $37.6 billion. $59 billion appropriated for military establishments.

10 *Allies invade Sicily.*

War Production Board assigns highest priority ratings to 96 gasoline projects scheduled for completion in 1943.

19 Completion of Texas-to-East-Coast 24-inch emergency pipe line.

Aug. *3* Local Selective Service Boards ordered to reclassify draft age fathers from Class III-A. Essential work rather than dependency made chief grounds for deferment.

Sept. *4* Byrnes announces West Coast Manpower Program, effective September 15.

Oct. *20* War Contracts Price Adjustment Board formed to handle renegotiation problems of procurement agencies.

Nov. *30* War Production Board adopts policy authorizing production of additional civilian goods as manpower, facilities and materials become available.

Dec. *2* Program Determination 473 (Amendment 1) issued to assist war housing projects.

24 General Eisenhower named to command Allied Invasion Armies.

1944

Jan. *1* Construction value of facilities put in place reaches $41.7 billion. Eighty-four per cent of war construction job completed.

9 Forrestal announces program of 65,000 landing craft.

11 War Production Board decides not to relax its facilities policy.

Jan.	*19*	War Production Board reports production of 86,000 planes in 1943, and a program of 100,000 heavier planes for 1944.
Feb.	*15*	Baruch and Hancock *Report on War and Post-War Adjustment Policies* is submitted to War Mobilization Director James F. Byrnes.
	22	Armed Services vigorously oppose any increase in civilian production until after invasion of Western Europe.
	29	War Production Board and National Housing Agency jointly issue policy statement: H-1 programs as set forth in this agreement limit war housing to immigrant war workers.
Apr.	*1*	War Production Board delegates authority to process housing applications to National Housing Agency.
	18	War Contracts Price Adjustment Board issues basic regulations on renegotiation of war contracts.
	19	W.P.B. Regional and District offices authorized to process construction applications up to $100,000.
	24	W.P.B. Planning Division issues first three parts of its study of reconversion.
June	*6*	*Invasion of France on Normandy Coast.*
	14	*U.S. troops land on Saipan in Marianas, 1,500 miles from Tokyo.*
	22	"GI Bill of Rights" approved by President, providing financial and educational benefits for veterans.
		$27.6 billion appropriated for the Navy.
	28	$49 billion appropriated for the War Department.
July	*1*	Value of facilities put in place amounts to $44.2 billion.
		War Manpower Commission begins system of nationwide manpower priorities to offset shortage of 200,000 workers in essential war production.
		Contract Settlement Act approved. Robert H. Hinckley named Director of Office of Contract Settlement.
	15	First of Nelson's reconversion orders, removing restrictions on use of aluminum and magnesium is issued.

July *17* War Production Board approves proposal of National Housing Agency to institute an H-2 housing program.

Aug. *3* Delegates from United States Chamber of Commerce discuss problems of construction during reconversion period with Nelson.

4 Byrnes announces new Manpower Controls on unessential industries in tight labor areas.

15 Priorities Regulation 25, spot authorization for civilian production, issued.

19 Limitation Order L-41 amended to permit manufacturers to install any processing machinery or equipment.

25 *Liberation of Paris.*

31 Public utilities permitted to make minor plant additions and extensions up to $10,000 without obtaining approval from Office of War Utilities of War Production Board.

Sept. *3* *American tanks cross German Frontier near Aachen, British troops enter Brussels.*

5 War Production Board adopts policy of extensive removal of controls on V-E Day.

15 Majority of Construction Controls Sub-Committee recommends repeal of Limitation Order L-41 under certain conditions.

18 Limitation Order L-41 amended to remove restrictions on building construction for public utilities.

28 Amendment to Direction 2 under Limitation Order L-41 makes it unnecessary to get permission of War Production Board to install or relocate any piece of processing or service machinery or equipment.

Order L-196, controlling sale of certain critical types of used construction machinery, revoked.

30 J. A. Krug succeeds Nelson as Chairman of the War Production Board.

Oct. *3* Office of War Mobilization and Reconversion established under James F. Byrnes.

Oct.	*15*	W.P.B. Construction Bureau formed, including former Facilities Bureau and related industry divisions. John J. McComb appointed director.
	17	War Production Board and National Housing Agency jointly agree to relax restrictions on construction, design, and use of materials for houses.
	23–27	*Japanese Navy defeated decisively in two naval battles of the Philippines.*
	23	Schedule A of Controlled Materials Plan Regulation 6 amended to permit builders to use certain materials or products formerly prohibited or restricted.
	26	By Program Determination 625 (Amendment 1) sales prices for war housing are limited to $8,000 and shelter rental to $65 per month per dwelling unit.
Nov.	*24*	Krug announces heavy increase in Mortar Shell and Small Arms Ammunition Programs.
Dec.		The Battle of the Bulge in Western Europe temporarily checks all plans for reconversion.
	28	John L. Haynes succeeds Arthur J. McComb as Director of Construction Bureau; McComb appointed Deputy Vice Chairman for Operations.
1945		
Jan.	*1*	Construction value of facilities put in place soars to $46.9 billion. Ninety-five per cent of war construction job completed.
		James F. Byrnes, Director of War Mobilization and Reconversion, issues his first report on problems of mobilization and reconversion.
	9	*American troops land on Luzon in the Philippines.*
	10	*Nazis begin to withdraw in the "Battle of the Bulge."*
Feb.	*9*	Requirements Committee approves program of 30,000 prefabricated housing units for the United Kingdom.
Mar.	*7*	*U.S. First Army establishes first Rhine Bridgehead at Remagen.*

Apr. 1 *Okinawa Island invaded in largest Pacific operation to date. Lifeline to Japanese Southern Empire severed.*

3 Chairman Krug outlines Victory-in-Europe program for progressive freeing of national economy from wartime controls.

8 Committee on Period One established under J. D. Small; subsequently a Construction and Construction-Controls Committee under chairmanship of John L. Haynes is appointed.

10 Army announces it will halt construction on 12 new tank plants.

12 Death of Franklin D. Roosevelt, President of the United States; Vice President Harry S. Truman assumes office.

16 Production Executive Committee establishes criteria for granting AA-3 ratings to applicants for bottleneck tools, equipment and construction projects.

17 Chairman Krug announces details of a new reconversion policy and War Production Board's approval of a $50,000,000 machine tool program and a $35,000,000 construction program for reconversion of automobile industry.

26 Under Secretary of War Patterson announces 15 per cent reduction in military orders.

27 Direction 5 to Limitation Order L-41 covering construction projects for reconversion issued.

Chairman Krug announces Spot Authorization Plan in operation for approval of civilian production.

May 7 *German unconditional surrender signed in Rheims at 2:41 A. M.*

8 *V-E Day after five years and eight months of war in Europe. Ratification of surrender terms at Berlin.*

29 Controls on construction eased by amendment to L-41.

July 1 Value of facilities put in place total $49.1 billion.

Aug. 6 *First atomic bomb dropped on Hiroshima killing over 100,000 Japanese.*

14 *President Truman announces full acceptance of surrender terms by Japanese Government.*

Aug. *14* War Manpower Commission abolishes all remaining man-power controls.

15 Army reduces its 1945–46 Procurement Program from $29 to $6.5 billion.

Sept. 2 *V-J Day. Formal surrender of the Japanese Government aboard Battleship Missouri.*

18 Snyder and Krug announce end of restrictions on building and construction, effective October 15.

WARTIME CHIEFS OF FEDERAL AGENCIES ACTIVE IN THE WAR CONSTRUCTION PROGRAM

GENERAL BREHON B. SOMERVELL
Commanding General, Army Service Forces

LIEUTENANT GENERAL EUGENE REYBOLD
Chief of Engineers, U.S.A.

VICE ADMIRAL BEN MOREELL
Chief, Bureau of Yards and Docks, Navy Department

REAR ADMIRAL EMORY S. LAND
Chairman, United States Maritime Commission

HAROLD L. ICKES
Administrator, Petroleum Administration for War

MAJOR GENERAL PHILIP B. FLEMING
Administrator, Federal Works Agency

HARRY W. BASHORE
Commissioner, Bureau of Reclamation

DONALD M. NELSON
Chairman, War Production Board (Jan. 1942–Sept. 1944)

J. A. KRUG
Chairman, War Production Board (Oct. 1944–Nov. 1945)

THOMAS H. MACDONALD
Commissioner, Public Roads Administration

SAM H. HUSBANDS
President, Defense Plant Corporation

BRIGADIER GENERAL DONALD H. CONNALLY
Administrator, Civil Aeronautics Administration (1939–May 1942)

CHARLES I. STANTON
Administrator, Civil Aeronautics Administration (May 1942–Aug. 1944)

THEODORE P. WRIGHT
Administrator, Civil Aeronautics Administration (Sept. 1944 ——)

JOHN B. BLANDFORD
Administrator, National Housing Agency